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RECENT RESEARCHES IN THE WOLCOTT GIBBS MEMORIAL LABORATORY OF HARVARD UNIVERSITY[1]

THE Wolcott Gibbs Memorial Laboratory of Harvard University is one of the most significant monuments ever built in memory of a chemical investigator. So far as I know, only the Davy-Faraday Laboratory in London, the van't Hoff Laboratory in Utrecht, and the Hofmann Haus in Berlin equal it in importance. Because Professor Wolcott Gibbs was one of the founders and presidents of the National Academy of Sciences, an account of the memorial building and of its first fruits is especially appropriate here to-day.

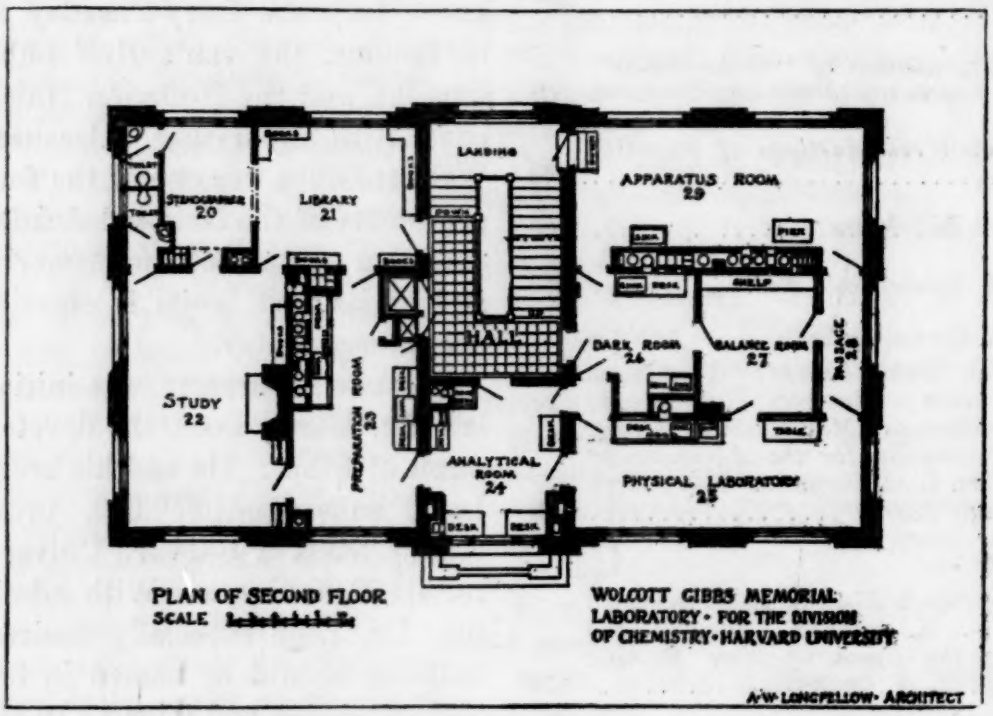
The new laboratory was initiated by the late Dr. Morris Loeb, the devoted and able pupil of Gibbs. He and his brother, James Loeb, subscribed $50,000, provided that other friends of Harvard University should raise $50,000 more. With admirable feeling, Dr. Loeb especially desired that the building should be named in honor of his former teacher and friend. In March, 1910, Dr. Alexander Forbes and other generous donors having greatly helped, the fund was completed; and in January, 1913, the building was opened for work, so that it has now been almost three years in full activity.

It is a great pleasure to express here the very lively gratitude, both on behalf of the university and on my own account, which I feel for the liberal interest of all these benefactors in the construction of this building.

Being the first of a large group of chem-

[1] Address delivered at the meeting of the National Academy of Sciences in New York, November 16, 1915.

ical laboratories planned for the department of chemistry at Harvard University, it was designed with especial care. Red "Harvard" brick with Indiana limestone trimmings, and Deer Isle granite foundations, constitute its external dress; the architectural details, due to A. W. Longfellow, are simple, effective and in good taste. It covers an area of 71 by 41 feet, and is 48 feet high. The construction is extremely solid and substantial, so that it is unusually free from vibration. Within, it is built of one, two or more investigators, according to the character of the work. There are many balance rooms, dark rooms and other necessities for accurate chemical experimentation, as well as rooms designed for both chemical and physical laboratories, because the work to be done lies on the border-line between chemistry and physics. Pipes are laid for hot and cold water, distilled water, steam, compressed air, oxygen and vacuum, as well as for gas; and electricity of many voltages is available at suitable plugs



brick and reenforced concrete; and although there is some woodwork in doors and furniture, the building is practically incombustible. Hollow bricks and doubly glazed windows with tight weather-strips protect it from heat and cold, and the temperature of almost every room is automatically regulated. The ventilating plant provides filtered air, hence the building is extraordinarily free from dust throughout. Because the laboratory was designed and is used wholly for research, it contains no lecture room, but is divided into many rather small rooms of different sizes, intended for throughout. An automatic electric lift is used for transferring the apparatus, and telephones connect all the important rooms. The building has six floors available for work: three regular stories, a very light and convenient basement, a sub-basement for especially constant temperature work entirely underground, and a practicable roof. Perhaps the most important feature in its design is the arrangement of the balance rooms, dark rooms and laboratories in suites, so planned as to give the greatest possible usefulness to each, in the manner illustrated by the right-hand side of the

plan of the second floor. The arrangement is similar, not only on both ends of the third floor, but on the western end of the ground floor. Rooms are provided in the basement for the storage and handling of apparatus, a workshop, storage batteries, switchboards and other purposes. But a complete description of this laboratory and of its virtues would take far too much time for the present occasion.[2] It is enough to say that the three years' work in it have shown it to be ideally adapted to the sort of investigation for which it had been planned.

In the front hall stands a bronze bust of Wolcott Gibbs with a marble tablet bearing the inscription:

WOLCOTT GIBBS
FEB 21 1822–DEC 9 1908
RUMFORD PROFESSOR
HARVARD UNIVERSITY
1863–1887 EMERITUS 1887–1908
PATHFINDER IN AMERICAN CHEMISTRY

With the building came a fund bearing an income sufficient for heating and janitor service, but not enough to purchase any suitable amount of special apparatus. Therefore, the subsidies which the director has received from the Carnegie Institution of Washington have been of very great use in providing part of the equipment of scientific apparatus and additional expert assistance. Indeed, without such help but little could have been done. I take great pleasure, therefore, in expressing my indebtedness to this institution, and feel that it shares with Harvard University and the generous founders in any credit which may be attached to the output of the laboratory. Also to the able assistants and advanced students who have helped me with so much patience and enthusiasm, I am deeply grateful. Twenty-four in number, they have been, of course, chiefly Americans (by no means all Harvard men), but the list includes four Canadians, an Icelander, a Dane, a Japanese, and a German. Moreover, the laboratory now harbors two guests, one conducting a research on the chemical activity of radium emanations and the other on the acidity of sea water. These two investigators are collaborating with colleagues who have no such suitable place elsewhere to offer for the investigations. Concerning these researches, however, it is not my province to speak.

What now has been the first fruit of this building? For the architectural shell is only a means, not an end in itself; and except as a memorial its existence is justified only by the work accomplished within it. During the past three years 24 papers have been published from this laboratory, and a number of other investigations have been almost finished and are being prepared for publication. Their character varies widely, ranging from almost pure chemistry to almost pure physics, but, in spite of the diversity, there is, for the most part, a common aim underlying them all. This aim is a careful study of the fundamental properties of the chemical elements—those substances which constitute the basis of our visible and tangible universe. Among these fundamental properties may be mentioned their atomic weights, their densities and compressibilities, their electromotive behavior and heat of combination with other elements and, finally, the physical and chemical properties of their simple compounds. Let us consider briefly the several investigations already published and now in progress.

Turning, first, to the study of atomic weights, three investigations on this subject have already yielded publications. The first of these was a research upon the atomic weight of carbon, in which sodium carbonate was prepared in an unusual degree of

[2] A fuller description of the laboratory was published in the *Harvard Alumni Bulletin* for March 26, 1913.

purity and converted into sodium bromide, the amount of silver necessary to precipitate the combined bromine being determined. In this way the relation between the atomic weights of bromine and carbon was determined, and the agreement of the values thus found with the parallel work of others gives very satisfactory evidence of the trustworthiness of all the other atomic weights which have been determined at Harvard in relation to bromine. Next came the study of the atomic weight of sulphur, which was studied in somewhat similar fashion, pure sodium carbonate being converted into pure sodium sulphate, and thus the relation between carbon and sulphur found through those salts. The value of sulphur obtained in this way was somewhat less than that ordinarily accepted, but not more than might reasonably be ascribed to the possible errors of previous work. On the whole, these two investigations, in which the purest sodium carbonate formed the starting point, add distinctly to one's confidence in the present accepted table of atomic weights. Both of these investigations were so extremely delicate and so very dependent upon pure, dust-free air that they could hardly have been executed at all in a less perfect building.

Next, during 1913–14 the atomic weight of lead from radioactive sources was studied; and we found that this sort of lead has an atomic weight distinctly lower than ordinary lead, although no known impurity could be found in it, and although its ultra-violet spectrum is identical with that of ordinary lead. This work was soon supported by independent and almost simultaneous but less complete and searching investigations published in Austria and France; and later has been reenforced by continued research in both continents. The outcome has unusual interest and significance, because it seems to indicate that there may be different kinds of lead having many properties precisely similar, but differing as to their atomic weights. The research is being continued at the Wolcott Gibbs Memorial Laboratory, large amounts of radioactive lead having been obtained from Australia, Colorado and Norway through the kindness of scientific friends.

Whatever may be the final outcome, one can not help thinking that researches of this kind deal with mysteries which are among the most fundamental of all those presented to the physical chemist, for the nature of the chemical elements underlies all the mechanism upon which life depends.

The study of compressibility was continued in two directions—on the one hand, the behavior under pressure of similar organic substances, and on the other hand, the compressibility of the elements, being carefully studied with increasing accuracy and effectiveness. This seems rather a strange subject to pursue in a chemical laboratory; but its interest is truly chemical, because of its relation to the recent theory of atomic compressibility, which gives a new interpretation of the mechanism of chemical action. There is not time to expound this theory at length here, but those who desire acquaintance with it will find a fairly complete résumé in the number of the *Journal of the American Chemical Society* for last December.[3] Suffice it to say that many facts may be interpreted to mean that the atoms are not hard, incompressible particles, but rather elastic, compressible, deformable entities, capable of yielding somewhat to every source of pressure which may be applied upon them. Moreover, evidence is available showing that both chemical affinity and cohesion exert pressure in their action, and hence affect the space

[3] *Jour. Am. Chem. Soc.*, 36, 2417–2439 (1914). Many references to other papers on this topic are given in the accompanying bibliography.

occupied by the atoms. In the interpretation of all the facts, knowledge of the compressibility of elements and compounds is essential; and as the available data are scarce, work in this direction was prosecuted with vigor. It is enough to say that the compressibility of over a score of organic substances and of nine elements (namely, tungsten, molybdenum, tantalum, boron, copper, iron, lead, thallium and mercury) have been determined during the last three years, either for the first time or at least with more accuracy than ever before. The apparatus for this purpose has been studied with a view to the detection of all the insidious minor errors which may affect work of this kind, and has been distinctly improved in several ways. Some of the theoretical outcomes of this work, which shows that the compressibilities of the elements are periodic, like their atomic volumes, have been briefly expounded in the July number of the new *Proceedings* of this academy. Here it is shown that the compressibility of the elements seems to depend in a large degree upon the atomic volumes and melting points of the several elements.

A revision of thermochemical data, which has been in progress for a number of years, has been especially advanced during the last three years in the Wolcott Gibbs Memorial Laboratory. The method of protecting a calorimeter from accidental heating or cooling, by always keeping the jacket around it at just the same temperature as the calorimeter itself, has been found efficient and convenient. Automatic contrivances called "synthermal regulators" for maintaining this identity of the two temperatures have been devised, and in various details the calorimetric procedure has been perfected. This method, by the way, which as applied to calorimeters of changing temperatures took its origin at Harvard, is spreading rapidly over the world, and has now adherents not only in various parts of America, but even so far away as Moscow.

The heat given out by the combustion of many organic substances has been studied, especial emphasis having been laid upon the danger of incompletely burning the more volatile compounds, which evaporate too quickly to be burned all at once; and precautions have been perfected for preventing this error. In addition, methods for determining the heat evolved during the solution of metals in acids, the neutralization of acids and alkalies, as well as for finding the specific heats of solutions—data which form the basis of all the thermochemistry of metallic salts—have been improved and amplified. In connection with these researches upon the heat evolved in chemical action, a study of methods of calibrating thermometers, of determining fixed points upon them by the transition temperatures of pure salts, and of subdividing the intervals between the fixed points in various ways so as to correspond exactly to the true temperature scale, has been carefully conducted. Also, considerable time was spent upon the further investigation of floating equilibrium—the point at which a sunken sealed float of fixed volume neither rises nor sinks in a liquid. The effect of concentration of various solutions on the temperature of this equilibrium was studied, as well as the slight volume changes suffered by the float with time, temperature and pressure. It has been shown that with due care this phenomenon may be used for either analyzing solutions or standardizing thermometers.

An interesting physico-chemical problem connected with the study of transition temperatures is the effect upon the crystalline "melting points" of impurities which crystallize out with deposited salts. In par-

ticular, the effect of sodium sulphate on the "melting point" of hydrated sodium chromate, and the effect of strontium bromide on strontium chloride, were both carefully studied.

Another investigation allied both to that just mentioned and to the work on compressibility, is the effect of pressure upon the solubility of salts. Theoretically as well as experimentally this is not a new subject, but there is still great need for the procuring of accurate data. A small but practicable apparatus was devised, making possible the determination of this effect as far as 600 atmospheres pressure, and preliminary results have already been obtained upon a number of typical salts. These investigations also are still being continued.

Turning now to the electrochemical side of our activities: during the past three years we have studied anew the precautions necessary in order to determine exactly the weight of silver deposited from its solutions by the galvanic current—a problem which has a distinctly practical bearing, in that the weight of deposited silver is one of the most satisfactory measures of the quantity of electricity flowing through the solution. There can be little doubt that this weight is in precise accord with the demands of Faraday's law of electrolysis, that is to say, is directly dependent upon the atomic weight of silver; but disturbing circumstances enter into the actual determination and one of the most important outcomes of this work was to show once more that the silver under some circumstances may carry down with it appreciable amounts of the solution from which it was deposited, thus increasing its apparent weight and leading to a somewhat erroneous estimate of the relation between quantity of electricity and quantity of substance. This investigation is being continued not only at this laboratory, but also at the Bureau of Standards and at Princeton University.

The electromotive forces manifested by metals and amalgams in appropriate solutions have a significant bearing on the energetic side of chemistry, being concerned not only with the important effect of concentration on chemical change, but also with chemical affinity itself. On this account these electromotive forces have not been neglected in the Gibbs Laboratory, the behavior of concentrated thallium amalgams and alloys of sodium and lead having received attention. The interesting details of these experimental researches are too technical and too elaborate for a brief statement of this kind.

Yet another electrical phenomenon investigated was the dielectric behavior of non-conducting organic substances. The dielectric constants of nearly a score of very pure organic substances were determined by means of a modification of a standard method, which was improved and made much more sensitive and accurate.

In keeping with the plan to study and compare all the important physical properties of typical chemical substances, the densities, melting points and boiling points of many substances mentioned above, which had been purified with very great care, were determined, taking pains about accuracy in the thermometric measurements not usual in chemical laboratories. It is especially interesting, in view of the difficulty of complete purification, to have all these various properties determined on the same uniformly pure samples of material, so that the true correlation between the different properties can be discovered; for, obviously, if one sample containing one set of impurities is used for determining density, and another sample with another set of impurities is used for determining the boiling point, any relation which may

exist between these two properties may be quite obscured by the different impurities. This is what generally happens when different people study the properties of varying samples.

One of the most recently undertaken of all these investigations is the study of surface tension of these same organic liquids. Surface tension, as you well know, is that tendency (caused doubtless by the cohesion of the molecules of substance) which forces any liquid surface to contract as much as possible, thus making drops and bubbles spherical, and drawing liquids up in capillary tubes. Surface tension is of peculiar interest in relation to the theory of compressible atoms, because it gives another clue to the cohesive forces holding matter together in the liquid and solid condition; but the published data even for such a common substance as water vary widely, often as much as 10 per cent. Hence the more careful study of this important property formed a legitimate part of the scheme of investigation for which the Wolcott Gibbs Memorial Laboratory was planned. In the first year of this research, which is being continued at the present time, we were able to find most of the important causes of the serious divergences in earlier work. Many of the experimenters had immersed their capillary tubes (in which the effect was to be measured) in other tubes much too narrow for the purpose, not realizing that even a tube one inch in diameter causes an appreciable "capillary" rise of the liquid contained within it. Again, they failed to allow for optical imperfections in the glass of the tubes containing the liquid, their methods of measurement were sometimes inadequate, and the mathematical formulæ used for calculating the results were often faulty. Therefore, in our preliminary work, which was reviewed briefly in the July number of the *Proceedings* of this academy, it is hoped that a distinct advance has been made.

If high quality had not been sought, of course the number of investigations could have been much greater. Some one has wisely said that the output of physico-chemical work is inversely proportional to the square of the grade of accuracy desired. In the brief space of these few minutes it has been impossible to give much more than a mere list. Those of you who are specially interested will find many of the researches already published in full; brief accounts of others are in the Year Books of the Carnegie Institution of Washington, and before long it is hoped that the rest also may be printed.

An investigator for whom much has been done feels gravely the responsibility which rests upon him of doing much in return; and although in this case he feels the necessary human inadequacy and incompleteness of the work just described, nevertheless he hopes that at least a beginning of accomplishment has been made, and that in the future the Wolcott Gibbs Memorial Laboratory, through many years, will yield ever increasingly useful additions to the sum of human knowledge.

THEODORE W. RICHARDS
HARVARD UNIVERSITY

THE LIFE OF RADIUM

THE life of radium, or the length of time required for a given quantity of radium to be transformed and converted into other elements, is a physical magnitude of considerable importance and interest. Its chief significance lies perhaps within the special field of radioactivity where radium occupies a unique position in being the only highly radioactive radio-element which possesses physical and chemical properties, and occurs in a sufficiently high state of

concentration, to permit its being obtained in reasonable quantities in an isolated and purified condition. For this reason radium is considered and accepted as a standard or typical radioactive substance, and its physical and chemical properties, including the value of its atomic weight, are known with a considerable degree of precision. For some time in the future, therefore, radium will occupy this position of relative importance and will serve as the basis for calculation and comparison with other radio-elements possessing less striking chemical individuality.

An accurate knowledge of the life of radium is also important in the field of geology, because of a method which is available for estimating the geological antiquity of some of the older rocks and minerals. This method is dependent on the determination of the progress of the radioactive disintegration which has taken place in those minerals containing appreciable proportions of uranium. For the accurate calculation of these important magnitudes an exact knowledge of the rate of disintegration of radium is essential.

It is possible, moreover, to obtain an estimate of the probable life of radium by a calculation involving as its basis a number of other important physical constants. These constants will be referred to more specifically later. If a knowledge of the life of radium can be arrived at by experimental methods not directly involving these constants, then, if the results given by the different methods are in good agreement, there is good reason for assuming that the accepted values for these constants are not very different from the true values.

The disintegration of radioactive substances is of such a character that the transformation of the substance into other elements can be expressed by a law in which the rate of transformation is an exponential function of the time. The rate of transformation is independent of the amount of material undergoing disintegration and is independent of the temperature, the pressure or of any other external condition to which we can subject the radioactive substance. It proceeds in such a manner that if half of the material present is transformed in a given period of time, half the remaining quantity will be transformed in a subsequent time of equal duration, and half the amount still left will undergo change in the third equal interval. This will continue indefinitely until the amount remaining will be too small to merit consideration. Since under these conditions some of the atoms of the radio-element will have an inappreciably short life, while others will have an inconceivably long one, it is impossible to attach any special significance to the term "life of" a radio-element except under certain definite restrictions. The life of a radio-element may therefore be somewhat dogmatically expressed in terms of the time required for exactly one half of it to be transformed into other substances. This constant is known as its "half-value period," and it is the half-value period of radium which particularly concerns us at the present moment.

The first estimate of the probable life of radium was published by Sir Ernest Rutherford in the first edition of his text-book "Radio-activity (Cambridge, 1904). In the disintegration theory proposed by Rutherford and Soddy the assumption was made that the expulsion of α-particles by radium and other radio-active substances was coincident with the changes taking place on the disruption of the atoms, namely, that the appearance of the α-particles was indicative of the simultaneous breaking up of the atoms of the radio-element. Rutherford further postulated the theory that each α-particle had its

origin in the disintegration of a single atom, or in other words, that each changing atom gave rise to a single α-particle. If this assumption were correct, then an estimate of the total number of α-particles emitted by any radioactive substance would afford a basis for judging as to the number of atoms which underwent transformation in any given period. From the results of experiments by Wien on the number of β-particles projected from one gram of radium bromide, and from considerations based on the ionization produced in a gas by the α-particles emitted by a known quantity of radium, Rutherford reached the conclusion that one gram of pure radium element expelled 2.5×10^{10} α-particles per second. From data based on experimental evidence it was assumed that the number of molecules in one cubic centimeter of hydrogen at standard pressure and temperature was 3.6×10^{19}. Taking the atomic weight of radium as 225 it was then calculated that there were 1.8×10^{21} atoms in 1 gram of radium.[1]

If the total number of atoms present was 1.8×10^{21} and the number transformed per second was 2.5×10^{10}, then the fraction of the whole undergoing change per second would be 1.4×10^{-11}, and per year 4.4×10^{-4}. This indicated that the half-value period of radium was about 1,500 years.[2]

Another estimate of the life of radium was made by Rutherford in the Bakerian lecture delivered before the Royal Society in May, 1904. Assuming that the heating effect, which had been observed and measured by P. Curie in radium salts, was due to the bombardment of the salt by the α-particles emitted from the radium which it contained and concluding that heat energy which appeared was derived from the kinetic energy of the moving α-particles, Rutherford calculated the kinetic energy of a single α-particle on the basis of the data then available. This he found to be 6×10^{-6} erg per second. The heating effect of about 100 gram calories per hour observed for one gram of radium corresponded to 1.2×10^{6} erg per second. Considering the radium salt as containing four α-ray products (Ra, Ra Em, Ra A and Ra C) and assuming an equal distribution of the heating effect between these, it therefore appeared that the number of α-particles expelled per second per gram of radium itself (and therefore the number of atoms of radium breaking up per second) was 5×10^{10}. Applying the same line of reasoning as had been used in the first instance for deriving the number of atoms in one gram of radium, Rutherford obtained the value of 800 years for the half-value period of radium.[3]

In the year 1905 Rutherford[4] performed an experiment in which the electrical charge carried by the α-particles from a known quantity of radium was measured. This was found to be equivalent to 4.07×10^{-9} ampere per second for the particles emitted by one gram of radium. Assuming the charge on each particle to be the same in value but opposite in sign to the charge carried by a single electron; viz., 1.13×10^{-19} coulomb, this gave the number of α-particles per second from one gram of radium as 6.2×10^{10}. Estimating, in this case without the previous error, the number of atoms in one gram of radium as 3.6×10^{21}, the value obtained for the rate of change of radium corresponds to a half-value period of about 1,300 years.

A new and more accurate determination

[1] An error was made in this calculation, and the correct number based on the data used should have been 3.6×10^{21}. This would have given 3,000 years for the half-value period.

[2] See preceding footnote.

[3] The error mentioned previously was repeated here, and the correct value given by this calculation is not 800, but 1,600 years.

[4] *Phil. Mag.*, 10, p. 193.

of the deflection of the α-particles from radium in a magnetic and an electric field was made in 1906 by Rutherford.[5] This gave a value of 5.1×10^3 for the ratio of the charge to the mass (e/m) of an α-particle. Since the value of e/m for the hydrogen ion in the electrolysis of water is nearly 10^4, Rutherford decided that of a number of possible explanations of these two differing values, the most probable one was that the α-particle consisted of an atom of the element helium (atomic weight 4) with a charge twice that of the electron. If this assumption is introduced into the last previously considered calculation of the life of radium, the number for the half-value period comes out 2,600 years instead of 1,300 years.

In 1908 Rutherford and Geiger[6] devised an experiment in which the actual number of α-particles emitted by a known quantity of radium could be accurately counted. They also accurately measured the charge carried by a known number of these particles, and demonstrated the correctness of Rutherford's earlier assumption that the charge on a single particle was twice that carried by a single electron. From the counting experiments it was evident that the number of α-particles emitted per second from one gram of radium was 3.57×10^{10}. The results of these experiments also gave data from which a more accurate estimate could be made of the number of atoms in one gram of hydrogen, viz., 6.2×10^{23}. Using the numbers thus derived the magnitude of the half-value period of radium was again calculated and found to be 1,690 years.

A direct determination of the rate of disintegration of radium by measurements of the decrease in radioactivity of a given radium salt is not practicable from an experimental standpoint. The rate of disintegration is so relatively slow and the experimental difficulties of accurately measuring the very small yearly decrease in the amount of radium present are so insurmountable that this method of attacking the problem is practically excluded. There is, however, a way in which a knowledge of the life of radium can be obtained which depends upon very different principles from those involved in calculations employed by Rutherford. This method was first suggested and applied by the writer, and its general principles can be briefly described as follows:

The work of Boltwood, McCoy and others has conclusively demonstrated that radium is a transition product in the radioactive disintegration of the element uranium. The sources of radium consist solely of old minerals containing uranium. In these natural compounds the uranium has been undergoing transformation for long periods of time and the products of its disintegration have been accumulating and have been retained in association with the unchanged uranium in the mineral. Now the nature of the successive changes occurring in radioactive substances is such that, in any system such as that represented by a uranium mineral, after sufficient time has elapsed a comparatively simple relation will exist between the quantities of the different genetically connected elements present. The condition finally attained is known as a state of radioactive equilibrium. In this state a simple expression will define the relative amounts of the different, related radio-elements contained in the mineral, and, what is more important to our immediate interests, a very simple relation will exist between the amounts of the different radio-elements undergoing transformation in equal periods of time.

The rate of change of a radio-element is,

[5] *Phil. Mag.*, 11, p. 348.

[6] *Proceedings of the Royal Society*, A, 81, p. 141; *ibid.*, A, 81, p. 162.

so far as our knowledge extends, an unalterable and unvarying factor. It may be defined in terms of the fraction of the whole amount of the element present which undergoes transformation in any convenient unit of time, a year for example. This factor is called the constant of disintegration of the radio-element. Its character is such that if P represents the number of atoms of a radio-element initially present, e is the base of the natural system of logarithms, t is the time expressed in the chosen units, and λ is the disintegration constant; then the number of atoms, P_t, of the element which will remain unchanged after the expiration of an interval t units from the start will be expressed by

$$P_t = Pe^{-\lambda t}.$$

Now, in any radioactive system comprising a parent substance like uranium and a series of disintegration products, including radium, for example, when a state of radioactive equilibrium has been established the conditions will be such that the number of atoms of each of the radio-elements in the series which undergo change in a given interval will be the same and equal. Thus if U be the number of atoms of uranium and λ_1 be its constant of change, and if Ra be the number of atoms of radium with a constant of change λ_2, then $\lambda_1 U = \lambda_2 Ra$, and this will also equal the product of the *number of atoms* of any other radio-element in the series multiplied by *its* disintegration constant. It should be evident from these considerations that the quantity (number of atoms) of radium formed in any given interval will be equal to the quantity (number of atoms) of radium which is transformed in the same interval, an essential requirement to the postulated condition of equilibrium. If, then, we can determine by experiment the quantity of radium which is formed in such a system, we obtain through this a direct measure of the quantity of radium which has changed to other elements during the observed period, and if we know the amount of radium present in the system we can determine the ratio of the two amounts which will be the disintegration constant of the radium. If radium were formed directly from uranium it would be easily possible to separate the uranium from a quantity of mineral containing a known amount of radium, purify it from all but traces of radium, allow it to remain until measurable amounts of radium had been produced within it, and then compare the radium formed from the uranium with the radium present initially in the mineral. This was attempted, but it was found that the rate of production of radium was too slow to be determined with any accuracy and was far less than was to be expected from theoretical considerations. This obstacle was overcome when in 1907 the writer was able to separate from uranium minerals a previously unidentified radio-element which was intermediate between uranium and radium in the series of atomic transformations, and which by its own disintegration produced radium in readily measurable quantities. To this element the name "ionium" was given. It thus became possible to separate the ionium from a mineral containing a known amount of radium, and to determine the rate of growth of radium in this ionium. This is a measure of the rate of production of radium in the mineral and therefore a measure of the rate of disintegration of the radium.

The two diagrams (Figs. 1 and 2) will perhaps be useful in making the general conditions and method of procedure more easily understood to those without a technical knowledge of the subject. In the first (Fig. 1) the amount of uranium changing per year relative to the total

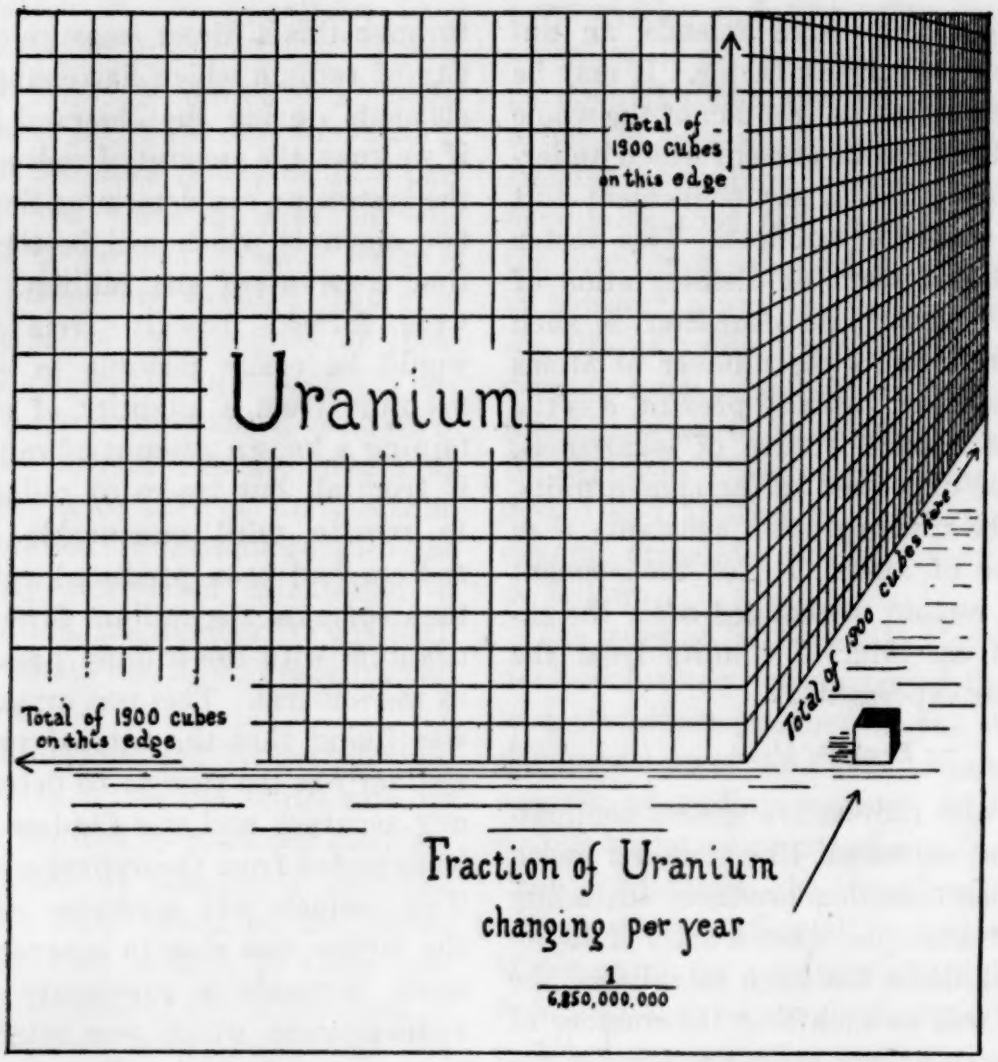

Total of 1900 cubes on this edge
Uranium
Total of 1900 cubes on this edge
Total of 1900 cubes here
Fraction of Uranium changing per year
1
6,850,000,000

Fig. 1.

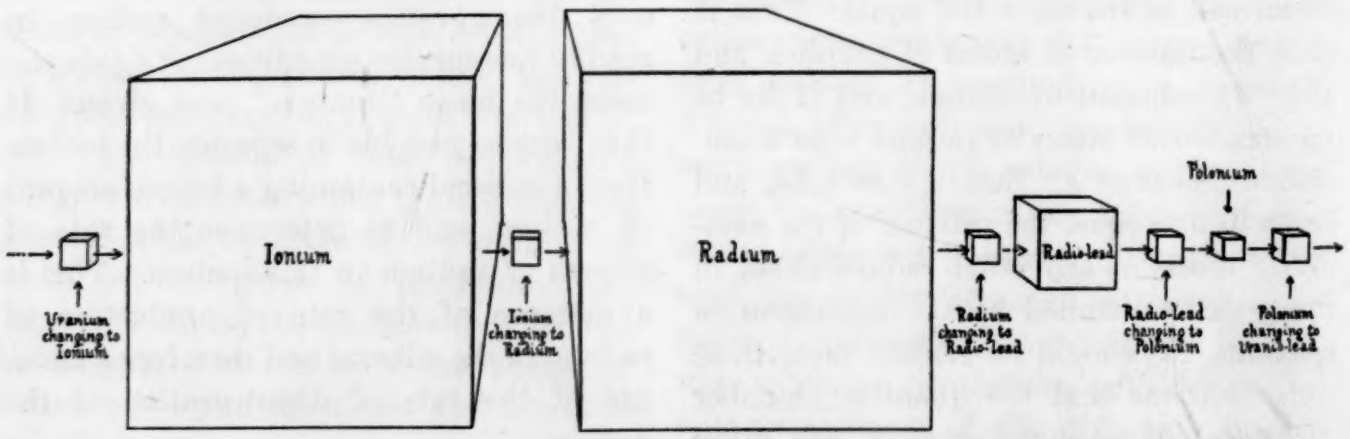


Fig. 2.

amount present is shown by two cubes whose volumes are proportional to the number of atoms involved in the transformation. In the second diagram (Fig. 2) the first cube on the left is supposed to be of the same size as the smaller cube in the first figure. Since the constant of change of ionium is as yet undetermined, it has been assumed for convenience to be approximately the same as that of radium, and the amount of ionium in the mineral is therefore indicated as of the same order as the amount of radium. With this limitation, and omitting the slight complications in-

volved by the existence of branch products, like actinium, and products of a rapid rate of change, like the emanation and radium-A, the diagrams represent the general conditions and changes to be found in an old[7] uranium mineral. The chief relation of interest shown by the diagram is that since the radium changing to radio-lead can not be determined experimentally with sufficient exactness, it is equally satisfactory and very much simpler to determine the ionium changing to radium and compare its quantity with the total amount of radium in the mineral. As a matter of fact the actual amounts of radium involved in these two quantities need not be known, it is only their relative values which are required, since the value of the disintegration constant is determined by the ratio of one of these to the other. In this respect the method is independent of any standard of purity of radium preparations, an advantage which is not possessed by other methods which have been used for attacking the problem. Thus, for example, the estimate of the half-value period of radium made by Rutherford and Geiger as a result of their experiments in 1908, had to be altered from 1,760 years to 1,690 years, when in 1912 the present international radium standard was adopted.

The results of a number of experiments conducted by the writer according to the method just outlined were published in 1908. In the most satisfactory of these experiments the mineral taken was a quantity of pure, primary North Carolina uraninite, almost free from secondary alteration products. About 40 grams of this material were used and the ionium was separated (with the thorium, which has identical chemical properties) by the ordinary analytical methods for the separation of thorium. The growth of radium in this preparation of ionium was then measured over a period of 147 days, and a rate of change for radium corresponding to a half-value period of 1,990 years was obtained. The results of the other experiments were in fair agreement with this value, which was assumed to be the most probable one. It is interesting to point out that this estimate was made between the time of Rutherford's estimate of 2,600 years and Rutherford and Geiger's estimate of 1,760 years.

In view of the disagreement of the value obtained by the "growing" experiment with the value as calculated from Rutherford and Geiger's work, it was reasonable to suspect that in the "growing" experiments all of the ionium was not separated from the mineral. Such a suggestion was, in fact, made subsequently by Rutherford. A careful investigation of some of the conditions associated with the usual methods employed for the chemical separation of small proportions of thorium from large amounts of uranium, indicated that a complete separation of the thorium under such conditions was extremely uncertain if not altogether impossible. The chemical behavior of uranium and thorium are strikingly similar: in the case of the uranous (UO_2) salts the chemical analogy of the two elements is such a close one as to make any separation at all almost impossible. Since an incomplete separation of the ionium would lead to *too small* a production of radium in the growing experiments, under the assumption that the separation was complete the calculated half-value period of radium would receive too high a value. It was therefore highly desirable that the experiments should be repeated under conditions which would avoid any uncertainty, and which would give an altogether trustworthy value for the life of radium as determined by this method.

[7] There are well-known examples of minerals too young for a state of equilibrium to have yet been reached between their radioactive constituents.

This work was undertaken in the university year 1913–14 in my laboratory by Miss Ellen Gleditsch, who came to this country from Norway for a year of study on a fellowship of the American Scandinavian Foundation. The work has been carried out in a very satisfactory manner and, after encountering a number of difficulties, she has quite recently completed her experiments at the University of Kristiania. A paper by her on the subject will appear in the January number of the *American Journal of Science.*

Miss Gleditsch carried out four separate operations, which may be briefly described as follows:

The *first* was with a specimen of very pure North Carolina uraninite weighing 110 grams and containing 2.46×10^{-5} gram of radium. The growth of radium from the ionium separated from this material gave a value for the constant of change of 3.7×10^{-4} (per year), which corresponds to a half-value period of *1,836* years.

The *second* was with a specimen of Norwegian uraninite known as Cleveite, weighing 180 grams and containing 3.2×10^{-5} gram of radium. The ionium separated from this material grew radium at a rate corresponding to a value for the constant of 3.9×10^{-4} and a half-value period of *1,780* years.

The *third* was with a specimen of Norwegian uraninite of the variety known as Bröggerite, weighing 200 grams and containing 4.1×10^{-4} gram of radium. In this experiment the radium grew at a rate corresponding to 4.2×10^{-4} for the value of the constant and indicated a half-value period of *1,640* years.

In the *fourth* experiment a specimen of very pure Bröggerite was used, weighing 100 grams and containing 2.1×10^{-5} gram of radium. The value obtained for the constant of change of radium was 4.1×10^{-4} and the half-value period corresponds to approximately *1,670* years.

In this series of experiments the methods for effecting a complete separation of the ionium were progressively developed and improved. In the last two, the ones in which bröggerite was used, there were definite indications that a complete separation had been accomplished. Moreover, Miss Gleditsch also measured the amount of radium in one of my original ionium solutions in which the radium had been growing for a period of nearly seven years and found that the rate of growth had been constant throughout the entire interval. This fact disposes of the possible objection that the life of ionium is too short to give an accurate value for the constant of radium as determined by this method.

It is therefore apparent that the different methods which have been used for estimating the life of radium give results which are in excellent agreement with one another. This agreement increases the assurance with which the estimated values of certain important physical constants involved in the calculation can be accepted as approximating closely to the true values. As a matter of interest these constants will be mentioned.

Number of α-particles emitted per second by one gram of radium (element) $= 3.57 \times 10^{-10}$.

The charge carried by a hydrogen ion in electrolysis $= 4.65 \times 10^{-10}$ E.S. units.

The number of atoms in one gram of hydrogen $= 6.2 \times 10^{23}$.

The mass of the hydrogen atom $= 1.61 \times 10^{-24}$ gram.

The number of molecules in one cubic centimeter of any gas at standard pressure and temperature $= 2.72 \times 10^{19}$.

The volume of the radium emanation in equilibrium with one gram of radium

= 0.62 cu. mm. calculated, = 0.63 cu. mm. found.

The rate of production of helium per year per gram of radium = 163 cu. mm. calculated, = 164 cu. mm. found.

B. B. BOLTWOOD

A SUGGESTED EXPLANATION OF "ORTHOGENESIS" IN PLANTS

THE purpose of this paper is not to discuss what is called orthogenesis in plants in general, but to cite certain notable illustrations of it, and to suggest a possible explanation. There may be some difference of opinion as to the proper definition of orthogenesis, but it is used in this paper as standing for progressive evolution in a given direction, in contrast with more or less successful variations in several directions, involved in the theories of natural selection and mutation.

My thesis is not to prove that orthogenesis differs in kind from such explanations of evolution as natural selection or mutation, but that the persistent variation which results in what is called orthogenesis is in response to a persistent change in the conditions of living. It is an explanation of orthogenesis which contradicts its original meaning and makes it a physical rather than a vitalistic phenomenon.

Another prefatory statement should be made. The conclusions reached in this paper are not simply inferences from a series of observations, but are based chiefly upon the results of experimental work which indicates that the changes called for can be induced as responses to changed conditions.

The gymnosperms are unique among the great plant groups in the length of their available history, recorded in such a way that our knowledge of the group may be said to be fairly continuous. Other great groups are either relatively short-lived, or their records, at least so far as our knowledge of them is concerned, are very discontinuous. As a consequence, many lines of advance among gymnosperms can be traced in unbroken series from the Devonian to the present time, involving structures that have been assumed to be beyond the influences of external conditions. I wish to call attention to four such lines of advance, and to draw certain conclusions which have some bearing upon evolutionary theory.

1. *The Egg.*—A remarkable series of progressive changes is recorded as one traces the development of the female sex organ (archegonium) from the most primitive gymnosperms to the most recent. The gradual change consists in the shifting of the time of appearance of the archegonium in the ontogeny of the gametophyte (the sexual individual). In the most primitive gymnosperms the archegonia appear at what may be called the full maturity of the gametophyte, just as they do in the prothallia of ordinary ferns. An unbroken series can be traced, representing an earlier and earlier appearance of archegonia in the ontogeny of the gametophyte, extending from full maturity to very early embryonic stages. In this ontogeny three stages may be roughly distinguished: (1) free nuclear division; (2) primary wall formation; (3) growth of tissue. It is toward the end of the third stage that archegonia appear in the most primitive gymnosperms; and the gymnosperms of to-day, whose archegonia are late in appearing, as the Cycads, are primitive in this feature, though they may be advanced in some others.

As one proceeds with the history of the group, it can be observed that the appearance of archegonia shifts back through the third stage, more and more tissue being developed after their appearance. Next they are observed forming at the second stage, that of primary wall formation. In

Torreya, for example, as soon as there are walled cells at all, the archegonium initials become recognizable; and all of the tissue development (the so-called endosperm) appears after the archegonia are under way.

Finally the shift is made into the first stage of gametophyte development, that of free nuclear division, so that, of course, there is no archegonium initial, and no archegonium, as in *Gnetum,* the egg being organized in connection with a free nucleus. If one were to continue this progress into Angiosperms, he would find eggs appearing earlier and earlier in the free nuclear stage of the gametophyte, so that the free nuclei are relatively few when eggs are organized; and recently a form has been found in which the megaspore nucleus organizes an egg directly, so that this backward movement in ontogeny has reached its limit, at least in one extreme case.

Such a series of progressive changes in gymnosperms, and there are several others equally distinct, furnishes us perhaps our most impressive illustration of what Naegeli called "progressive evolution," which we have come to call orthogenesis. Here is a steady progress in a given direction through an immeasurable lapse of time, during which, presumably, the plants have been exposed to every conceivable change of conditions.

Recent experimental work upon sexuality in plants, however, may suggest an explanation for this phenomenon among gymnosperms. It is now known that the appearance of gametes (the sexual cells) is in response to certain conditions affecting metabolism. When the gamete is associated with a sex organ, as the archegonium, the conditions for gamete formation are the conditions for archegonium formation. In other words, the essential response is the gamete; a sex organ may or may not be involved. Speaking in very general terms, the conditions that favor gamete formation are associated with minimum vegetative activity. These conditions may affect the plant as a whole, in such forms as algæ, or only certain protoplasts, and in them the sex response occurs. It follows in the case of our gymnosperms that any change of conditions shortening the period of vegetative activity, would thereby hasten the appearance of eggs in the ontogeny of the gametophyte. This is exactly the result that would follow the differentiation of the year into definite seasons. In other words, this progressive change in the time of the appearance of the eggs of gymnosperms seems to hold some relation to the evolution of climate. It is significant, perhaps, that the two great living groups of gymnosperms, Cycads and Conifers, are contrasted not only in the feature under discussion, but also in geographic distribution. The Cycads, primitive in the late appearance of eggs, are tropical; while the Conifers, advanced in the early appearance of eggs, are found in the sharply differentiated seasons of the temperate regions. In any event, we know that a gamete is a response to conditions affecting unfavorably the ordinary metabolism of a plant; and the most regularly recurring variable that affects natural vegetation is climate.

2. *The Proembryo.*—A parallel illustration of progressive evolution is presented by the proembryo of gymnosperms. Unfortunately the embryos of paleozoic gymnosperms have not as yet been found, not because they did not exist, as some have imagined, but because we have not been sectioning the proper seeds. In any event, it is now becoming safe to predict their general character.

In the most primitive gymnosperms the proembryo is an extensive tissue, completely filling the large egg, best illustrated by *Gingko* among living forms. Just as in the

case of nuclear division in any large cell, there is a certain amount of free nuclear division before wall formation begins. In these primitive gymnosperms successive free nuclear divisions continue until numerous free nuclei are distributed throughout the egg, and then primary wall formation fills the egg with proembryonic tissue, consisting sometimes of hundreds of cells. The progressive change consists in the earlier and earlier appearance of wall formation in the history of the embryo, thus restricting free nuclear division, and limiting the extent of proembryonic tissue.

In the Cycads, for example, permanent proembryonic tissue occurs in every amount, from almost filling the egg (not completely filling it, as in *Gingko*) to a relatively small amount at one pole of the egg, as in *Zamia*. When this type of change is followed into the Conifers, the proembryonic tissue is found to be reduced to a few cells, and in some of the Gnetales there is no free nuclear division, so that the proembryo, in the ordinary sense, has disappeared, a condition which characterizes the angiosperms. The conditions that favor wall formation and inhibit continued free nuclear division are, of course, unknown in a definite way, but that this phenomenon is a response to some progressive change in conditions is evident.

After recognizing the kind of changes that influence gamete formation, and that perhaps explain the progressive evolution of the archegonium situation, it is of interest to discover whether these two series of progressive changes in general proceed *pari passu*. Without going into details, it may be said in general that they do. In other words, forms whose archegonia appear toward the maturity of the gametophyte have large proembryos; while those forms that have eliminated archegonia have also eliminated proembryos (that is, in the gymnosperm sense of free nuclear division as a preliminary stage). Whether declining metabolic activity favors wall formation, as contrasted with free nuclear division, as it certainly does gamete formation, I am not prepared to say; but the situation lends itself to experimental answer.

These two illustrations of progressive evolution suggest that orthogenesis does not differ from other kinds of evolution in being some kind of determinate mechanism that does not respond to a changing environment, but only in that it is a response to some progressive evolution of environment. Of course, we all realize that the word environment covers a tremendous complex of interacting factors, which the ecologist is trying to disentangle. The point made here, however, is not to suggest the factors that have been instrumental in bringing these changes to pass, but to suggest that the factors, whatever they may be, are external, and that the changes are responses. If the change is progressive, the variation in conditions is progressive.

3. *The Cotyledons.*—No feature of the embryo of gymnosperms has been more discussed than their mixture of dicotyledony and polycotyledony. The discussion has revolved about the conviction that one of these conditions must be primitive and the other derived from it. To some, dicotyledony is the primitive condition, because Cycads and Bennettitales are dicotyledonous, and they seem most primitive in other features. According to this view polycotyledony has been derived from dicotyledony by splitting. To others, polycotyledony is the primitive condition, chiefly because it is characteristic of Abietineæ, and in that case dicotyledony has been derived from it by fusion.

It would be a boon to one or the other of these schools if the embryos of Cycadofilicales or Cordaitales should be discovered, and found to be positively either polycoty-

ledonous or dicotyledonous. My prophecy is that they will be found to be both. A study of cotyledony in general has shown that these two conditions, and also monocotyledony, are merely different, and often variable final expressions of a common method of development. A cotyledonary zone or ring always develops around the growing point, and upon this ring a variable number of primordia appear, nearly always more than finally develop. The whole ring continues to develop in connection with one or two or more growing points, the others having been checked by conditions easily explained by the ontogeny of the embryo, especially by the time and position of the appearance of the immediately succeeding members. When one finds not only dicotyledony, but also polycotyledony, among the Monocotyledons, it becomes apparent that the number of cotyledons is a variable. The wonder is that it is as constant as it appears to be.

The interesting evolutionary feature is that polycotyledony is so much more common among gymnosperms than among angiosperms. It is perhaps safe to say that it was as common among most primitive gymnosperms as was dicotyledony; or rather that the number of cotyledons was much more variable than in any living group of seed plants. This interesting situation is still further emphasized by the remarkable constancy of dicotyledony in the Dicotyledons and of monocotyledony in the Monocotyledons, but I know of none of them in which less than four cotyledonary growing points start. The conditions that seem to determine the number of cotyledons to be developed by a cotyledonary ring are too numerous to be discussed here, but in general they have to do with the rate of growth of the subsequent members of the embryo. For example, if the subsequent leaves begin to appear almost immediately and develop vigorously, the cotyledonary ring usually becomes one-sided in development, and the result is a single large cotyledon in an apparently terminal position. Many monocotyledonous embryos, in which for some reason there is an elongation of the stem before the first leaves begin a vigorous growth, develop two cotyledons, as in the case of numerous grasses. This is the usual sequence in Dicotyledons; while in polycotyledonous forms there is much delay in the appearance of the subsequent members, and no inhibition of cotyledon primordia. All this variation in the number of cotyledons suggests variations in the conditions of growth, since it depends upon rate of growth in the so-called "plumule."

4. *The Seed.*—Another noteworthy illustration of progressive evolution in gymnosperms, associated with the same conditions that seem to have determined the changes previously cited, is the progressive simplification of the ovule and seed. As yet the most primitive ovule is not available, and the hiatus in our knowledge between the fern sporangium or sorus, and the most primitive known ovule is complete. In that unknown region heterospory developed, and then the seed-forming ovule, but the steps are left to conjecture. The interesting fact, however, is that the most primitive ovules and seeds we know are the most complex, and that there has been a progressive simplification through the whole series of seed plants. This simplification has not only involved the layers of the testa, as often pointed out; but its gradual progress is most completely shown by the vascular supply to the ovule and seed. The very gradual elimination of the vascular elements is a measure of the progressive simplification of the whole structure. We have found that the vascular supply does not determine the structure; but the structure determines the vascular

supply. Ovule and seed formation are associated with the closing activities of a period of growth, and any shortening of this period by a sharp differentiation of seasons should leave some impress upon ovule and seed development. This progressive simplification of the ovule deserves attention in the effort to discover its conditions; and the whole story, excepting the introductory chapter, is recorded in the history of gymnosperms.

In conclusion it may be emphasized that the gymnosperms, with their unparalleled perspective, are not only of importance in connection with the problems of the origin of seed plants and of angiosperms, but also in developing some conception of evolutionary progress quite apart from fluctuating variations or even mutations, and certainly beyond the control of any experimental work in genetics. It is obvious now that the phenomenon of progressive evolution in plants is not to be explained by any so-called "inherent tendency," but rather as a continuous response to progressive changes in the conditions for vegetative activity. When these conditions are analyzed, the response called orthogenesis in plants will become to some extent an index of the evolution of climate.

JOHN M. COULTER
UNIVERSITY OF CHICAGO

THE CONVOCATION WEEK MEETINGS OF SCIENTIFIC SOCIETIES

THE American Association for the Advancement of Science and the national scientific societies named below will meet at Columbus, Ohio, during convocation week, beginning on Monday, December 27, 1915:

American Association for the Advancement of Science.—President Dr. W. W. Campbell, Director Lick Observatory; retiring president, Dr. Charles W. Eliot, Harvard University; permanent secretary, Dr. L. O. Howard, Smithsonian Institution, Washington, D. C.; general secretary, Mr. Henry Skinner, Academy of Natural Sciences, Logan Square, Philadelphia, Pa.; secretary of the council, Professor W. E. Henderson, Ohio State University.

Section A—Mathematics and Astronomy.—Vice-president, Professor A. O. Leuschner, University of California; secretary, Professor Forest R. Moulton, University of Chicago, Chicago, Ill.

Section B—Physics.—Vice-president, Professor Frederick Slate, University of California; secretary, Dr. W. J. Humphreys, U. S. Weather Bureau, Washington, D. C.

Section C—Chemistry.—Vice-president, Professor W. McPherson, Ohio State University; secretary, Dr. John Johnston, Geophysical Laboratory, Washington, D. C.

Section D—Mechanical Science and Engineering.—Vice-president, Bion J. Arnold, Chicago; secretary, Professor Arthur H. Blanchard, Columbia University, New York City.

Section E—Geology and Geography.—Vice-president, Professor C. S. Prosser, Ohio State University; secretary, Professor George F. Kay, University of Iowa.

Section F—Zoology.—Vice-president, Professor V. L. Kellogg, Stanford University; secretary, Professor Herbert V. Neal, Tufts College, Mass.

Section G—Botany.—Vice-president, Professor W. A. Setchell, University of California; secretary, Professor W. J. V. Osterhout, Harvard University, Cambridge, Mass.

Section H—Anthropology and Psychology.—Vice-president, Professor G. M. Stratton, University of California; secretary, Professor George Grant MacCurdy, Yale University; New Haven, Conn.

Section I—Social and Economic Science.—Vice-president, Geo. F. Kunz, New York; secretary, Seymour C. Loomis, 69 Church St., New Haven, Conn.

Section K—Physiology and Experimental Medicine.—Vice-president, Professor F. P. Gay, University of California; secretary, Professor C.-E. A. Winslow, Yale University.

Section L—Education.—Vice-president, Professor E. P. Cubberley, Stanford University; secretary, Dr. Stuart A. Courtis, Detroit, Mich.

Section M—Agriculture.—Vice-president, Professor Eugene Davenport, University of Illinois; secretary, Dr. E. W. Allen, U. S. Department of Agriculture, Washington, D. C.

COLUMBUS

The American Physical Society.—December 28–30. President, Professor Ernest Merritt, Cornell University; secretary, Professor A. D. Cole, Ohio State University, Columbus, Ohio.

The American Federation of Teachers of the Mathematical and the Natural Sciences.—Secretary, Dr. Wm. A. Hedrick, McKinley Manual Training School, Washington, D. C.

The American Society of Naturalists.—December 30. President, Professor Frank R. Lillie, University of Chicago; secretary, Dr. Bradley M. Davis, University of Pennsylvania, Philadelphia, Pa.

The American Society of Zoologists.—December 28–30. President, Professor William A. Locy, Northwestern University; secretary, Dr. Caswell Grave, The Johns Hopkins University, Baltimore, Md.

The Entomological Society of America.—December 29–31. President, Professor Vernon L. Kellogg, Stanford University; secretary, Professor Alexander D. MacGillivray, 603 West Michigan Ave., Urbana, Ill.

The American Association of Economic Entomologists.—December 27–30. President, Professor Glen W. Herrick, Cornell University; secretary, A. F. Burgess, Melrose Highlands, Mass.

The Botanical Society of America.—President, Professor John M. Coulter, University of Chicago; secretary, H. H. Bartlett, 335 Packard St., Ann Arbor, Mich.

The American Phytopathological Society.—December 28–31. President, Professor H. H. Whetzel, Cornell University; secretary, Dr. C. L. Shear, U. S. Department of Agriculture, Washington, D. C.

American Nature-Study Society.—December 30–31. President, Dr. L. H. Bailey, Ithaca, N. Y.; secretary, Professor E. R. Downing, University of Chicago, Chicago, Ill.

School Garden Association of America.—December 29–30. President, Van Evrie Kilpatrick, 124 West 30th St., New York, N. Y.

American Association of Official Horticultural Inspectors.—December 28–29. Chairman, W. E. Rumsey, Morgantown, W. Va.; secretary, Professor J. G. Saunders, State Capitol, Madison, Wis.

The American Microscopical Society.—December 29. President, Professor Chas. A. Kofoid, University of California; secretary, T. W. Galloway, James Millikin University, Decatur, Ill.

American Mathematical Society (Chicago Section).—December 30 to January 1. Chairman, Professor E. J. Wilczynski, University of Chicago; secretary, Professor H. E. Slaught, 5548 Kenwood Avenue, Chicago, Ill.

The Southern Society for Philosophy and Psychology.—December 28–30. President, Professor J. C. Barnes, Maryville College; secretary, Professor L. R. Geissler, University of Georgia, Athens, Ga.

Botanists of the Central States.—Will hold no separate meeting, but will present its papers in connection with Section G. President, Professor H. C. Cowles, University of Chicago; secretary, Dr. Edward A. Burt, Missouri Botanical Garden, St. Louis, Mo.

Society for Horticultural Science.—December 28–29. President, W. L. Howard; secretary, Professor C. P. Close, College Park, Maryland.

Association of Official Seed Analysts of North America.—December 28 and 29. President, W. L. Oswald; secretary, John P. Heylar, Agricultural Experiment Station, New Brunswick, N. J.

Society of Sigma XI.—December 28. President, Chas. S. Howe, Case School; secretary, Professor Henry B. Ward, University of Illinois, Urbana, Ill.

BOSTON

The American Physiological Society.—December 27–29. President, Professor W. B. Cannon, Harvard Medical School, Boston, Mass.; secretary, Professor Chas. W. Greene, University of Missouri, Columbia, Mo.

The American Society of Biological Chemists.—December 27–30. President, Professor Walter Jones, The Johns Hopkins University; secretary, Professor Philip A. Shaffer, Washington University Medical School, St. Louis, Mo.

The Society of Pharmacology and Experimental Therapeutics.—December 27–29. President, Dr. Torald Sollmann, Western Reserve University Medical School, Cleveland, Ohio; secretary, Dr. John Auer, Rockefeller Institute for Medical Research, New York City.

WASHINGTON, D. C.

The Geological Society of America.—December 28–30. President, Professor A. P. Coleman, University of Toronto; secretary, Dr. Edmund Otis Hovey, American Museum of Natural History, New York City.

The Association of American Geographers.—December 30–January 1. President, Professor R. E. Dodge, Teachers College, Columbia University;

secretary, Dr. Isaiah Bowman, Broadway and 156th St., New York City.

The Paleontological Society.—December 29–30. President, Dr. E. O. Ulrich, U. S. Geological Survey; secretary, Dr. R. S. Bassler, U. S. National Museum, Washington, D. C.

The American Anthropological Association.—December 27–31. President, F. W. Hodge, Bureau of American Ethnology; secretary, Professor George Grant MacCurdy, Yale University, New Haven, Conn.

The American Folk-Lore Society.—Convocation Week. President, Dr. P. E. Goddard, American Museum of Natural History, New York City; sectary, Dr. Charles Peabody, 197 Brattle St., Cambridge, Mass.

The American Economic Association.—December 28–30. President, Professor W. F. Willcox, Cornell University; secretary, Professor Allyn A. Young, Cornell University, Ithaca, N. Y.

The American Sociological Society.—December 28–31. President, Professor E. A. Ross, University of Wisconsin; secretary, Professor Scott E. W. Bedford, University of Chicago, Chicago, Ill.

NEW HAVEN

The Association of American Anatomists.—December 28–30. President, Professor G. Carl Huber, University of Michigan; secretary, Dr. Charles R. Stockard, Cornell University Medical School, New York City.

URBANA

The Society of American Bacteriologists.—December 28–30. President, Dr. D. H. Bergey, University of Pennsylvania; secretary, Dr. A. Parker Hitchens, Glenolden, Pa.

NEW YORK CITY

The American Mathematical Society.—December 27–28. President, Professor E. W. Brown, Yale University; secretary, Professor F. N. Cole, 501 West 116th St., New York City.

CHICAGO

The American Psychological Association.—December 28–30. President, Professor John B. Watson, The Johns Hopkins University; secretary, Professor R. M. Ogden, University of Kansas, Lawrence, Kansas.

PHILADELPHIA

The American Philosophical Association.—December 28–30. President, Professor A. C. Armstrong, Wesleyan University; secretary, Professor E. G. Spaulding, Princeton, N. J.

SCIENTIFIC NOTES AND NEWS

THE Royal medals of the Royal Society have been awarded to Sir Joseph Larmor, F.R.S., for his contributions to mathematical and physical science, and to Dr. W. H. R. Rivers, F.R.S., for his contributions to ethnography and ethnology. The Copley medal is awarded to Professor Ivan Petrovitch Pavlov, for his investigations in the physiology of digestion and of the higher centers of the nervous system; the Davy medal to Professor Paul Sabatier, for his researches on contact action and the application of finely-divided metals as catalytic agents, and the Hughes medal to Professor Paul Langevin, for his contributions to electrical science.

THE Symons Memorial gold medal of the Royal Meteorological Society has been awarded to Dr. C. A. Angot, director of the French Meteorological Bureau.

DR. HENRY SHOEMAKER CONARD, professor of botany at Grinnell College, has been appointed visiting lecturer on botany at Harvard University for the second half of the academic year.

DR. W. A. ORTON and Dr. C. L. Shear, of the United States Department of Agriculture, have been appointed delegates from the American Phytopathological Society to the Second Pan-American Congress meeting in Washington, December 27 to January 8.

STAFF-SURGEON G. M. LEVICK has been specially promoted to the rank of fleet surgeon in the British navy for his services with the British antarctic expedition in 1910.

DR. WILFRID T. GRENFELL, known for his work in Labrador, has accepted an invitation to take charge of a division of a hospital unit sent to France by Harvard University. He will return in the spring to Labrador.

DR. WILLIAM H. HEATH, of Buffalo, has been appointed executive medical adviser and sanitarian to the king of Siam. His duty will be to establish modern sanitary conditions in that country.

H. H. CLAYTON, in charge of the forecast department for the Argentine Weather Bureau, is returning to this country for a visit.

Word has reached the American Museum of Natural History that both the Crocker Land expedition and the relief party sent to its aid will spend the winter ice-bound in the Arctic. Letters received from Donald B. MacMillan, leader of the Crocker Land expedition, by way of Copenhagen, said that the men of his party were in good health and were preparing to spend the winter in the Arctic regions, and to continue explorations in the spring. Dr. Edmund O. Hovey, who is leading the relief party on the steamer *George B. Cluett,* reports his ship frozen in at North Star Bay, 120 miles north of Etah, the base of the MacMillan expedition.

The third regular meeting of the session of the New York Section of the American Chemical Society was held in Rumford Hall, on the evening of December 10, in conjunction with the New York Section of the Society of Chemical Industry and the American Electrochemical Society. This meeting was the second of the series dealing with the subject of "University and Industry." The speakers announced were Richard C. Maclaurin, president, Massachusetts Institute of Technology; Henry P. Talbot, professor of inorganic chemistry, Massachusetts Institute of Technology; William H. Walker, professor of chemical engineering, Massachusetts Institute of Technology; Arthur D. Little, member of corporation, Massachusetts Institute of Technology. These papers were followed by an address on "The Naval Consulting Board of the United States," by Dr. L. H. Baekeland and Dr. W. R. Whitney, members of the board.

Professor W. S. Franklin recently gave two addresses before the Physical Science Club of Oberlin College. His subjects were: "Bill's School and Mine" and "Some Phenomena of Fluid Motion—The Curved Flight of a Baseball."

Professor G. A. Mitchell, director of the Leander McCormick Observatory, University of Virginia, lectured at the Brooklyn Institute of Arts and Sciences, on November 20, on "The Exact Distances of the Stars." On November 22 he lectured in Harrisburg before the Natural History Society on "The Sun."

Dr. John Pogue Stewart, professor of experimental pomology in the Pennsylvania State College, addressed the Illinois State Horticultural Society at the University of Illinois, on December 15 and 17. The subjects presented were "Methods of Influencing Yield and Commercial Quality in Apples" and "Latest Developments in Sulphur Sprays."

A bronze statue of Captain R. F. Scott, R.N., subscribed for by officers of the British navy, has been erected in Waterloo Place, London. The statue, which shows the explorer in polar dress, is the work of Lady Scott. Mr. A. J. Balfour, first lord of the admiralty, unveiled the statue on November 5.

Carl Axel Robert Lundin, maker of many of the largest telescopic lenses in the world, died at his home in Cambridge on November 28.

Professor Edouard Prillieux, member of the French Academy of Sciences, known for his work in botany and especially phytopathology, died on October 8, at the age of eighty-six years.

Professor Hans Gross, a distinguished Austrian criminologist, has died at the age of sixty-eight years.

Section M (Agriculture) of the American Association for the Advancement of Science will hold two sessions, in Townsend Hall, University of Ohio, on Tuesday, December 28. The morning session, at 10 o'clock, will be devoted to the vice-presidential address of Professor L. H. Bailey, on "The Forthcoming Situation in Agricultural Work." At the afternoon session at 2 o'clock, a symposium will be presented on "The Relation of Science to Meat Production." The subject will be introduced by President W. O. Thompson, of Ohio State University, and will be developed by the following speakers:

President H. J. Waters, Kansas State Agricultural College, on "Food in Relation to Growth and Meat Production."

Professor L. D. Hall, Office of Markets, U. S. Department of Agriculture, on "Economic Aspects of Meat Production and Marketing."

Professor Herbert W. Mumford, University of

Illinois, on "The Problem of Meat Production on the High-priced Lands of the Middle West."

Dr. A. R. Ward, Bureau of Animal Industry, U. S. Department of Agriculture, on "Disease Control as a Factor in Meat Production."

THE kite photography expedition which has been making aerial views over the crater of Kilauea Volcano for the past six months under the expert direction of C. F. Haworth, C.E., has returned with a series of views from lofty positions, showing the volcano as it has never before been viewed. This difficult feat, under most trying conditions of winds, calms and volcanic emanations, has been done to add necessary data to the photographic survey made for the large naturalistic model of Kilauea which has now been under constant construction for nearly three years for the Harvard Geological Department, the first work of this class yet supported by American geologists. Only one other comparable work has been constructed in this country, the model of the coral island "Bora Bora," for the Agassiz Museum. These naturalistic land reliefs by the geologist land sculptor, Curtis, belong to a new field of geology, which is bringing a fresh and wider interest into the earth sciences.

THE *Journal* of the American Medical Association states that the damage suit against Rockefeller Institute for $200,000, brought by two of the former employees of the institute, was dismissed in the United States District Court on November 4. The plaintiffs in the case alleged that the doctors had persuaded them to submit to the injection of serum from which they had become infected with an incurable disease. The court held that the facts were insufficient to constitute a cause of action.

THE New School of Tropical Medicine and Research Laboratories in Calcutta are, according to the *Pioneer Mail,* as quoted by *Nature,* now ready for occupation. They will be associated with the Calcutta Medical College, so that a constant supply of tropical material will be available for study. A subject to which study will be devoted will be the pharmacology of Indian drugs. The number of research workers at present arranged for is eight.

DR. L. H. PENNINGTON, forest pathologist of the New York State College of Forestry at Syracuse, has just found the chestnut tree blight in a chestnut grove at Sand Ridge not far from Phoenix. This is the first report of an occurrence of the blight in this section of New York state. The presence of the blight in Oswego County indicates that the chestnut trees in all parts of the state will sooner or later be attacked. The occurrence of the blight at Sand Ridge is in the form of a spot infection where but a single tree is found to be infected. The tree in this instance was already completely girdled and killed and the fungi in fruiting condition. Other trees may therefore have been infected before this one was discovered and removed. If these spot infections can be discovered in time and the diseased trees removed and destroyed at once, the general spread of the disease may be retarded and the life of chestnut groves prolonged several years in this part of the state.

A GIFT of $1,000, unusual in the conditions under which it was offered, has been accepted by the trustees of Cornell University from an anonymous donor. The money was placed under the control of Professor G. D. Harris, of the department of geology, with the stipulation that "payments shall be made from the fund to Professor Harris as and when he requests and no accounts shall be required beyond simple receipts from Professor Harris saying that the sum or sums he may request from time to time have been received and that they are to be expended for purposes which in his opinion will be of assistance to a student or students of geology as the case may be." Following the stipulation concerning the use of the money the anonymous donor explained his position with a tribute to Professor Harris's work as geologist and teacher. "I may perhaps explain," writes the donor, "that it has been my privilege to attend courses at three universities, the University of Indiana, Cornell University and the University of Wisconsin, and at none of these have I known of any man who so fully as Professor Harris had the real training and development of his students at heart or who in so extreme a degree

of unselfishness lived only for their good and for the advancement of the science."

Registration for the new courses in public health administration, offered by the University and Bellevue Hospital Medical College, indicate that many health officers, both of the New York City's health department and from other localities of New York State, are taking work in compliance with the new requirement of the New York State Public Health Council. Those connected with the municipal health department who have enrolled for this work now number twenty, while the enrollment of those who have elected the correspondence method for meeting the new ruling has reached a total of fifty. The new courses, which were first offered by the university during the past summer, have been arranged in accordance with the new regulation of the Public Health Council, which has made it obligatory for health officers to supplement their professional education with further instruction in administering to the general health of the community. For students who have previously secured their M.D. degree, upon the completion of one year of study, including actual attendance at lectures and laboratory work, it is possible to earn the degree of doctor of public health.

From investigations carried on by the New York State College of Forestry, at Syracuse, in the basket willow growing section about Liverpool and Lyons in New York state and in the study of reports of basket manufacturers, it finds that the bulk of the willow ware used in the United States is manufactured in the little town of Liverpool, just north of Syracuse. The Liverpool shops use over 3,000 tons of basket willow stock which is 75 per cent. of the total stock used in the country. About a year ago basket willow stock was bringing from $20 to $25 per ton delivered at the Liverpool factories. To-day, owing to the cutting off of the foreign supply the prices average about $30 a ton, and that in spite of the increased local production. There are few industries using the products of the forests where there is as little waste as in the basket willow industry. The only part of the willow stem or cane that is thrown away is the bark. The College of Forestry is planning to carry on investigations in the Eastern Forest Products Laboratory to see whether the bark of the willow does not have some use as a source of certain chemical products. The returns from land upon which basket willow is grown are larger than the returns from any crop produced on lands in the state outside of nursery stock. Often land of little or no value because of its wet condition can be used for the growing of willow and as culture is not necessary there is practically no labor except at the time of cutting in the fall. Cutting is usually carried on in November and as the canes are taken out they are tied up in bundles of from 50 to 100 each. At the factory the canes are steamed, peeled and dried and are then ready for use. In sections about Liverpool and about Lyons it has been estimated that owners of willow holts often take in from fifty to one hundred dollars per acre per year over a growing period of 30 years.

UNIVERSITY AND EDUCATIONAL NEWS

A gift of $150,000 to Harvard University with which to found a professorship in archeology is contained in the will of Mrs. Eunice Melles Hudson, widow of a former president of the American Bell Telephone Company, which was filed for probate here.

On the recommendation of the minister of public instruction, there were created by a decree dated October 7, 1915, a chair of topographic anatomy and a chair of bacteriology in the Faculté de médecine of the University of Paris.

The committee of inquiry of the American Association of University Professors which is preparing a report on the case of Dr. Scott Nearing, of the University of Pennsylvania, consists of the following: Professors Davis R. Dewey, Massachusetts Institute of Technology; Henry Farnam, Yale University; F. H. Giddings, Columbia University; Roscoe Pound, Harvard University; A. O. Lovejoy, *Chairman,* Johns Hopkins University.

Dr. Frederick A. Wolf, plant pathologist of the Alabama Agricultural Experiment Sta-

tion, has accepted the position as head of the department of botany and plant pathology in the North Carolina Agricultural and Mechanical College, West Raleigh, N. C. He will enter upon his new duties on January 1.

ARTHUR S. RHOADS, who has a bachelor's and master's degree in science from the Pennsylvania State College, has recently taken a position as assistant in forest pathology in the New York College of Forestry.

DR. E. W. A. WALKER, fellow of University College, Oxford, has been appointed lecturer in pathology.

DISCUSSION AND CORRESPONDENCE

PRE-CAMBRIAN NOMENCLATURE

TO THE EDITOR OF SCIENCE: The State Geological Reports often contain facts which are of wide interest but which are liable to be overlooked. As all general conclusions must depend on local facts, it seems to me to be the duty of those who recognize the wide bearing of these local facts to bring them to public notice. I have just received a book[1] in which the results of the "Contributions to Pre-Cambrian Geology" by R. C. Allen, affect not merely Michigan, but the whole subject of Pre-Cambrian nomenclature. For instance the very interesting and valuable tables published by Miller and Knight showing the correlation of Pre-Cambrian rocks[2] might be revised by the authors in view of this publication.

Now the main point is this: Andrew C. Lawson in his study of the pre-Cambrian rocks urges that the Animikie, which has always been considered a part of the Huronian period, is a period independent of, and later than the Huronian period. The author, R. C. Allen, shows good reason to believe that the Gogebic which has always been correlated with the Animikie should be correlated with the *middle* Huronian. He accordingly correlates the Animikie as *middle* Huronian. This seems to me to be worthy of mention in as much as Allen has not confined himself to work in Michigan but has worked in the original Animikie region. I first met him there.

Now, in view of these facts, I may put in print suspicions which I have only breathed in conversation, namely, that in the original Huronian where there are bright bits of jasper in the Thessalon conglomerate, they were derived from a *middle* iron-bearing series which is not well represented in that area. In view of the facts brought forward by Allen which indicate that the Gogebic was invaded by granite intrusions, and then later was overlaid unconformably by another formation, the Copps formation, it seems to me it would be very premature to make the changes suggested by Lawson or by Miller and Knight. I have no doubt the facts presented in this report will have to be carefully scrutinized by these writers, who will undoubtedly form their own conclusions.

In the meantime we must be very careful about trying to make widespread pre-Cambrian subdivisions. In any one district the division line between those strata affected by granite intrusions and metamorphosis and those not so affected is marked, and such was practically the line between the Huronian and Laurentian as originally mapped. But it becomes more and more clear that granite intrusions on a large scale have taken place in different regions at different dates. And it is very doubtful to me whether the habit of grouping granite intrusions under names which are more or less correlated with inter-geologic periods is a wise arrangement.

The same report contains a valuable paper by Case and Robinson which emphasizes and shows the correctness of the downward salients of Schuchert's curve showing the extent of the ocean in those times in the paleozoic section in Michigan. What we need to do for the pre-Cambrian is to adopt the same laborious process that Schuchert has completed and see if possibly different types of strata, such as the great Middle Huronian (Mio-Huronian) iron-bearing formation may not, as I have suggested, correlate with definite stages in the

[1] Pub. 18, Geol. Series 15, Mich. Geol. and Biol. Surv., by Allen and Barrett.

[2] P.-C. Geol. of SE. Ont., by Miller and Knight, Rep. Bureau of Mines, Vol. XXII.

evolution of air and ocean under the influence of early life. Mr. Allen has made an important contribution to pre-Cambrian geology, of far more than local value.

Alfred C. Lane

MEMBERS HOLDING LONGEST CONTINUOUS MEMBERSHIP IN THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Through a clerical oversight, by reason of the original list having been drawn up for another purpose, the following names were inadvertently omitted from the roll of those who now hold the longest continuous membership in the American Association, printed in Science for December 3. It will be noted that all in the following list are Life Fellows of the Association.

*Hitchcock, Charles Henry, Ph.D., LL.D., Honolulu, Hawaii. (11.) 1874. E.

*Lyman, Benjamin Smith, E.M., 708 Locust Street, Philadelphia, Pa. (15.) 1905. E.

*Gilbert, Grove Karl, LL.D., U. S. Geological Survey, Washington, D.C. (18.) 1874. E.

*Morse, Edward Sylvester, Ph.D., Peabody Museum, Salem, Mass. (18.) 1874. F, H.

*Stephens, W. Hudson, Lowville, N. Y. (18.) 1874. E, H.

*Warner, James D., 463 East 26th Street, Flatbush, Brooklyn, N. Y. (18.) 1874. A, B.

*Hanaman, Charles Edward, Troy, N. Y. (19.) 1883. F.

*Mendenhall, Thomas Corwin, Ph.D., Sc.D., LL.D., 329 North Chestnut St., Ravenna, Ohio. (20.) 1874. B.

L. O. Howard,
Permanent Secretary

PAN-AMERICAN

To the Editor of Science: Will you kindly tell me the scientific meaning of Pan-American? Is Canada in or out of the Pan?

Otto Klotz

Ottawa,
December 9, 1915

SCIENTIFIC BOOKS

Tierbau und Tierleben. Von R. Hesse und F. Doflein. Band 2. Das Tier als Glied des Naturganzen von F. Doflein. B. G. Teubner, Leipzig und Berlin. 8vo. Pp. xv + 960. 740 text illustrations and 20 plates.

The second volume of Hesse and Doflein's "Tierbau und Tierleben" has just been issued by Teubner, of Berlin and Leipzig. The first volume, from the pen of Professor Hesse, appeared in 1910 and dealt with the structure and functions of the animal body. The companion volume, the work of Professor Doflein, bears the date of 1914 and takes up the consideration of the animal as an element in nature. It is divided into three books. The first has to do with animals in their relations to their organic surroundings and deals with their feeding habits, their means of defense, their sexual life, their migrations, the care of their young, and their social life. The second book treats of animals in their relations to their inorganic environment, such as general cosmic changes, the surrounding medium and the substrate, the quantity and quality of food, temperature and climate, and light. The third and last book has to do with the adaptive structures and activities of animals, and the explanation of these phenomena. The volume contains almost a thousand pages and is illustrated by some twenty plates and over seven hundred text-figures. The press work, including the illustrations, is beautifully done. Gothic type, however, gives the page a less modern scientific aspect than Roman would have done. Some of the illustrations, like Fig. 574 of the sleeping places of Indian birds, verge more on the theatrical than on the natural; others, like Liljefors' grouse and wild-goose plates, are really wonderful works of art. Here and there a few mistakes are to be noted; thus Fig. 721 is incorrectly attributed to Packard. But in such a wealth of material it is impossible to comment critically. Suffice it to say that the immense body of new and accurate information brought together in this volume will make it a most welcome addition to the present source of information used by the modern zoological reader. G. H. Parker

Flora of New Mexico. By E. O. Wooton and Paul C. Standley. Contrib. U. S. National Museum, Vol. 19. 1915. Pp. 794.

Many years ago Professor E. O. Wooton, then in charge of the department of botany at the New Mexico Agricultural College, planned a flora of New Mexico. It was at first expected that the work would be finished in a few years, but various difficulties arose, while every new locality examined furnished additions to the list of species. Thus, as the years passed, the collections tended to run ahead of the work done on them, and the completion of the flora appeared more remote than ever. Eventually, Mr. Paul C. Standley became Professor Wooton's assistant, and through the joint labors of the two the flora made rapid progress; after both had moved to Washington, and were in a position to consult the larger herbaria, it was finally completed. It was then offered to the National Museum for publication, and met with the usual delays. Owing to its great size, it had to be condensed, everything not considered essential (*e. g.*, names of collectors) being cut out. As it now appears, it is a bulky volume, containing an enormous amount of information. The number of species treated in 2,975, but, as the authors state, the actually existing flora is doubtless much greater. Considerable areas in New Mexico have never yet been visited by a botanist, while others have only been superficially examined. Though the "Flora of New Mexico" is necessarily of the nature of a preliminary survey, it forms an excellent guide to the plants of the state, and is reasonably complete for all the better known localities. Each genus is briefly defined, all the species are included in very clearly written keys, and in addition there are numerous remarks which greatly facilitate the ready recognition of the various plants. The type locality, general range and range in New Mexico are given. It would be hard to imagine a more useful and adequate treatment of the subject within the space-limits imposed. After spending many hours in the study of the book, the reviewer finds his admiration for it increasing with greater familiarity, a process the reverse of that experienced in relation to some other works of the same general type. There may be, there certainly are, matters which will require amendment, but we appear to have the best presentation which years of study in the field and herbarium, and careful consideration of all the available evidence, can give at the present time.

The new species found in the course of the investigation have been very numerous, including members of such genera as *Yucca, Agave, Quercus, Clematis, Rosa* (two), *Amelanchier, Padus* (six), *Lupinus, Robinia, Rhus, Acer, Garrya, Sambucus,* etc., etc. Although New Mexico is bordered by Colorado on the north, it contains a very large number of species not found in the latter state. How many of these are really endemic or precinctive can not be ascertained until the plants of Arizona and Chihuahua are better known, but it is practically certain that several at least are confined to some of the large mountain groups. In discussing Wooton's cocklebur, *Xanthium commune Wootoni,* it is remarked that it appears to be a distinct species, but is not placed as such on account of the occurrence of *commune* and *Wootoni* burs in a single instance on the same plant. DeVries ("Species and Variation," 1905) grew *X. Wootoni* from seed, and found it to come true; in his discussion of it he provided a binomial designation. The reviewer, two years ago, found a specimen of *X. commune* in a greenhouse at Boulder, having several *Wootoni*-like burs, although no *X. Wootoni* has ever been seen in Colorado. We must apparently conclude that *X. Wootoni* is a valid species, but that *commune* from time to time varies or mutates to a virtually identical form.

T. D. A. COCKERELL
UNIVERSITY OF COLORADO

SCIENTIFIC JOURNALS AND ARTICLES

THE concluding (October) number of volume 16 of the *Transactions of the American Mathematical Society* contains the following papers:

W. V. LOVITT: "A type of singular points for a transformation of three variables."

J. K. LAMOND: "The reduction of multiple *L*-integrals of separated functions to iterated *L*-integrals."

G. A. Miller: "Independent generators of a group of finite order."

C. N. Haskins: "On the zeros of the function, $P(X)$, complementary to the incomplete gamma function."

Edward Kircher: "Group properties of the residue classes of certain Kronecker modular systems and some related generalizations in number theory."

C. de la Vallée Poussin: "Sur l'intégrale de Lebesgue."

G. E. Wahlin: "A new development of the theory of algebraic numbers."

A. F. Carpenter: "Ruled surfaces whose flecnode curves have plane branches."

The opening (October) number of volume 22 of the *Bulletin of the American Mathematical Society* contains: Report of the twenty-second summer meeting of the society, by Thomas Buck; "Groupless triad systems on fifteen elements," by Louise D. Cummings and H. S. White; "Note on Green's theorem," by C. A. Epperson; "Convergence of the series

$$\sum_{i=0}^{\infty}\sum_{j=0}^{\infty}\frac{x^i y^j}{i-j\gamma}$$

(γ irrational)," by W. D. MacMillan; "A certain class of functions connected with Fuchsian groups," by Arnold Emch; "Professor Bôcher's views concerning the geometry of inversion," by Eduard Study; "The Davis calculus," by E. W. Davis; "Notes"; and "New Publications."

The November number (Vol. 22, No. 2) of the *Bulletin* contains: "On the relation between linear algebras and continuous groups," by L. E. Dickson; "An aspect of the linear congruence with applications to the theory of Fermat's quotient," by H. S. Vandiver; "Limits of the degree of transitivity of substitution groups," by G. A. Miller; "The permutations of the natural numbers can not be well ordered," by A. B. Frizell; "Relations among parameters along the rational cubic curve," by J. E. Rowe; Review of Vallée Poussin's Cours d'Analyse Infinitésimale, third edition, by M. B. Porter; Review of Zeuthen's Lehrbuch der abzählenden Methoden der Geometrie, by E. S. Allen; Review of Carslaw's Teaching of Mathematics in Australia, by R. C. Archibald; "Shorter Notice": Loria's Per la Biografia di Giovanni Ceva, by D. E. Smith; "Notes"; and "New Publications."

SPECIAL ARTICLES

THE MOUNTING OF CELLOIDIN SECTIONS IN SERIES

Investigators in both normal and pathological plant histology have to often resort to celloidin for embedding parts of plants which contain a considerable amount of lignified tissue, as the sections are very apt to break up badly in cutting if the material is embedded in paraffin.

The process of cutting and mounting celloidin sections is very simple if only occasional sections are required for study, as they can be stained and mounted separately. It is sometimes desirable, however, to examine a whole series of sections, in which case it is necessary to stick the sections to a slide before staining them, which greatly increases the difficulty. Plowman[1] has described a method of this kind which very briefly is as follows: As the sections are cut they should be transferred to a piece of smooth thin paper, and when they are dry the paper should be turned face downward on a slide which has previously been coated with albumen fixative. Add several layers of paper, press down, and roll with a roller. Place another slide on top of the sections, clamp down, and dry for a few hours.

I have had occasion to use the above described method on various occasions with rather poor success. The paper is very apt to stick to the edges of the sections and either tear them badly or pull some of them away from the slide when the paper is finally removed. The use of oiled paper will not entirely obviate this difficulty unless the paper is very oily, in which case it is apt to prevent some of the sections from sticking to the slide if some of the oil gets beneath them. I have found, furthermore, that it is necessary to use a much thicker solution of albumen than for paraffin sections, which is apt to become deeply colored in the subsequent staining, resulting in messy looking slides.

[1] *Bot. Gaz.*, 37, pp. 456–461.

Land[2] has recently described a fixing fluid for paraffin sections which is much superior to the albumen fixative in general use. I have been using a similar fluid for some time and have found that it works equally well for celloidin sections, and much better than the albumen method of fixation as described by Plowman. Land gives a formula for making the fluid for paraffin sections, but for celloidin sections I have found that by placing a few small pieces of gum arabic in distilled water and shaking until the bubbles formed cease to break readily, enough of the gum will be dissolved to answer all purposes. A sufficient amount of potassium bichromate should be added to give the fluid a slightly yellow color. Land advises adding the bicromate when the sections are mounted, but by preserving the fluid in a blackened bottle it will keep in good condition for months.

Two methods may be used in mounting the sections. If they are small and the entire series can be arranged on one or two slides, the knife can be wet with 90 per cent. alcohol when cutting, and the sections removed to a clean slide as they are cut. After the slide has been covered with sections, the alcohol is allowed to dry, or is removed with a small piece of filter paper. A drop of the fixing fluid is now added and the slide tilted to allow it to run underneath the sections. The excess of fixing fluid should be removed by placing a piece of filter paper on top of the sections and gently pressing down. If care is exercised in doing this it is very seldom that any of the sections will adhere to the paper. Occasional sections that do adhere, however, can be easily removed from the paper and put in place again. Another slide should be slightly oiled and placed on top of the sections, after which it is clamped down. The slide should be left to dry in strong sunlight for a few hours.

If the sections are rather large and it is not necessary to save the entire series, the knife can be wet with glycerine alcohol and the sections removed to a large slide or piece of glass as they are cut. Such sections as are needed for study can be subsequently transferred to another slide, first carefully washing them to remove all traces of glycerine.

If care is taken in removing the excess of fixing fluid from the sections at the start, the oiled slide can be removed after drying without injuring any of them. I have mounted as many as one hundred rather large sections in series by this method and they all came through in perfect condition.

ALBAN STEWART
UNIVERSITY OF WISCONSIN

[2] *Bot. Gaz.*, 59, pp. 397–401.

THE RÔLE OF ANOPHELES PUNCTIPENNIS SAY IN THE TRANSMISSION OF MALARIA

As the result of recent experiments conducted in New Orleans, Louisiana, *Anopheles punctipennis* Say has proved itself to be an efficient medium for the development of the sexual cycle of the organism of tertian malaria, *Plasmodium vivax*.

Of previous attempts to determine the exact status of this species of *Anopheles* the most thorough was that of Hirschberg who in a series of carefully executed experiments obtained only negative results in infecting *A. punctipennis* with the gametes of estivo-autumnal malaria. As further evidence of this negative rôle, he states that no cases of malaria were found to be developing in a certain section of Maryland where the species was common, and that he had never found naturally infected *punctipennis* here or elsewhere as had been done with *A. quadrimaculatus*.

Dupree, however, in a list of efficient hosts of malaria includes *punctipennis* as having been so determined by himself. No other details are given and Knab in 1913 was inclined to the belief that he had in reality experimented with *A. punctipennis*, which is now recognized as a distinct species and as an efficient host.

Anopheles punctipennis is one of the common species of the genus in the United States and because of its abundance and wide distribution the question of its agency in the spread of malaria is an important one. To record the fact that the parasites of one form of the disease may successfully develop in this species is the purpose of the present note, which will

be followed by a more detailed account of experiments.

On November 6, 1915, six specimens of *A. punctipennis* were allowed to feed on a patient in whose blood had been demonstrated the gametes of tertian malaria. The mosquitoes had been bred from larvæ and before and after the blood meal were given only raisins and water as food. They were kept at room temperature and were dissected and examined in the usual way after intervals of 7 days (two specimens), 9, 18, 20 and 24 days. The first four showed a moderate to heavy infection of the stomach with oocysts. In the one examined on the twentieth day were found mostly rupturing and ruptured oocysts and an intense invasion of the salivary glands with sporozoites —the form which is inoculated by the mosquito into the human host. The sixth specimen alone proved to be negative and in this one the condition of the ovaries suggested the explanation that this may have been due to the ingestion of only a small amount of infective blood.

On a second case of tertian malaria having a much fewer number of gametes, a single specimen of *A. punctipennis* was fed on November 12. Upon dissection on December 2, a light infection of both the stomach and glands was found to exist.

In each experiment bred specimens of *A. quadrimaculatus* were fed on the patients as controls and these also showed a high percentage of infections upon subsequent examinations.

The demonstration that *A. punctipennis* is an efficient host for tertian malaria does not necessarily indicate that it is an efficient carrier of other forms of malaria and, in fact, from Hirschberg's results we may anticipate that such is not the case.

The writer is indebted to Dr. C. C. Bass and Dr. F. M. Johns of the laboratories of clinical medicine of Tulane University for assistance in the work upon which this statement is based and to Mr. F. Knab for the verification of the determination of the mosquito.

W. V. King

Bureau of Entomology,
U. S. Department of Agriculture

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SECTION G, BOTANY

PACIFIC COAST MEETINGS

The following officers were present: Professor W. A. Setchell, sectional vice-president; Professor L. L. Burlingame, acting secretary. The meetings were held in the Hearst Mining Building, University of California, with the exception of the meeting on August 4, which was held in the Botany Building, Stanford University. The following papers were read:

Tuesday, August 3

The Embryo of the Gymnosperms: Professor John M. Coulter, University of Chicago.

Attention is called to three features of Gymnosperms: the proembryo, the archegonium and the cotyledons.

Proembryo.—The proembryo presents every gradation from a tissue completely filling a large egg to such segmentation of the egg as occurs in Angiosperms. This series represents a progressive change extending from the Devonian to the present time. No better example of progressive evolution, or orthogenesis, can be found. The change is due to the fact that wall-formation begins earlier and earlier in the history of the embryo, thus restricting free nuclear division and limiting the amount of proembryonic tissue. The conditions that favor wall-formation and inhibit continued free nuclear division are unknown, but that this phenomenon is a response to some progressive change in conditions is evident.

Archegonium.—A similar series of progressive changes is shown in the development of the archegonium, extending from the appearance of archegonia at the full maturity of the gametophyte, through forms in which they appear earlier and earlier in the ontogeny of the gametophyte, and ending with the maturation of eggs at the free nuclear stage, resulting in the elimination of archegonia. The conditions for gamete-formation as contrasted with those for vegetative activity, are getting to be known through experimental work. This progressive change, therefore, is to be explained by the gradual earlier appearance of conditions for gamete-formation, which in general are conditions of minimum vegetative activity. In all probability, these are the conditions that also favor earlier wall-formation in the ontogeny of the proembryo.

Cotyledons.—Evidence is now at hand to prove that polycotyledony and dicotyledony are merely

different final expressions of a common method of development. Polycotyledony was more common in the primitive gymnosperms; and neither coalescence nor splitting explains the two conditions.

Discussion: Professors Clements and Campbell.

Methods of Pollination and Evolution of the Male Gametophyte: L. L. BURLINGAME, Stanford University.

There are four types of pollination devices and male gametophytes found among the Gymnosperms as follows:

1. The Cycadofilicales and Cordiatales male gametophyte has numerous cells in its pollen grain. It is as yet uncertain whether they are spermatogenous or prothallial. No pollen tubes of any sort were formed. The pollen grains were lodged in pollen chambers in the nucellus.

2. The Cycadales have a single prothallial cell, a pollen chamber, swimming sperms and a haustorial pollen tube that is probably to be homologized with the rhizoid of their ancient Pteridophyte ancestors.

3. The Araucarian conifers have a multicellular prothallus, non-ciliated sperms, and a protruding nucellus without a pollen chamber. The pollen lodges on the ovuliferous scale at a distance from the nucellus and forms a long branching haustorial pollen. This tube is probably to be homologized with the germ tube and not the rhizoid of their pteridophytic ancestors. It is not homologous with that of the cycads, since it does not have the same function, grow in the same direction, and was probably derived from different ancestors.

The Abietinean conifers have short direct pollen tubes, two evanescent prothallial cells, and non-ciliated sperms. They could readily have been derived by reduction from the araucarian type. There seems to be very little probability of the reverse process, since such a course of evolution would be accomplished through a number of intermediate steps each of which is apparently distinctly disadvantageous to the plants adopting it.

Some Notes on Western Species of Cupressus: L. R. ABRAMS, Stanford University.

Among the Californian conifers the genus *Cupressus* occupies an important position in point of interest to the botanist, and especially to the plant geographer. The true cypresses belong to warm temperate climates, and are associated in our minds with the sunny Mediterranean countries. But *Cupressus* is not altogether an old world genus; fully half if not more of the species are North American, and more are in California than in any other one section.

Turning to the geological records we find that in Tertiary time *Cupressus* flourished in Greenland and northern Europe. The present far separated eastern and western branches, then, like torreyas and sequoias, are the remnants of a once widely distributed race. The local distribution of the California species, which seldom or never form forests but exist in small isolated groves, is also suggestive of a decadent race, once flourishing but now struggling against the invaders of a new age.

Up to the present time five species have been recognized in California: *C. macrocarpa* Hartw., *C. goveniana* Gord., *C. macnabiana* Murr., *C. sargentii* Jepson and *C. bakeri* Jepson. Two remote groves, little understood or unknown to those who have undertaken to monograph the genus, have proved after careful field studies to be distinct from other Californian species. Those of San Diego County, which previously have been placed in *goveniana*, are in no way related to that species, but belong to the smooth-trunked group represented by *guadalupensis*. The other, an hitherto unknown grove situated in the Piute Mountains is the only grove in the Sierra Nevada. This species has the glandular foliage of *macnabiana* and *bakeri*, but the fruit is more the nature of *goveniana*. It is unquestionably distinct from these, however, and is to be described as a new species.

Geologic History of the Gymnosperms: E. W. BERRY, Johns Hopkins University (read by FORREST SHREVE).

Wednesday, August 4

Morphogenic Effects of Light: GEORGE J. PEIRCE, Stanford University.

Stimuli are sometimes classified as formative and directive. The influence of a given stimulus may be due to its quantity, the direction from which it is received, etc. Then we find the *quantity* of light exercising a distinct effect upon the quantity, and inferentially upon the growth. This is plainer perhaps in parts of the world where the quantity of light falling upon the earth's surface is greater than elsewhere, owing to the dryness and cleanness of the atmosphere. The top of the forest and the upper surface of the chaparral are remarkably flat, despite the number of species composing each. That light is a factor in determining this is shown by the behavior of *Escholtzia*, bur clover, geranium, mint and other plants, wild and cultivated, coming up in chaparral, hedges, vines, etc. These ordinarily short plants may become extraordinarily long under these special conditions of light.

The *direction* from which light comes also determines the form which certain plants assume.

This is shown by plants cultivated from the spore upon a clinostat revolving a horizontal plane. To avoid error from single cultures, or from successive cultures on the same instrument or instruments, a multiple clinostat has been devised, which revolves forty or more turn-tables simultaneously. This weight-driven multiple clinostat will be shown to all interested.

Discussion: MacDougal and Clements.

Theories of Photosynthesis in the Light of Some New Facts: H. A. Spoehr, Department of Botanical Research, Carnegie Institution of Washington.

The Distribution and Succession of the Flowers of the Giant Cactus in Relation to Isolation: D. S. Johnson, Johns Hopkins University.

The flowers of *Carnegiea gigantea* growing about Tucson, are rarely symmetrically grouped about the growing point of the massive stem. They are usually most abundant on the east side and least abundant, or wanting, on the west side. If more evenly distributed about the circumference, the flowers are larger and open first on the east side. This is true of plants on all slopes and of branches as well as of the main axis.

The most evident external factors which may be concerned with this peculiar distribution of the flowers are sunlight and the air temperature. In the season of hot days and cold nights, prevailing when the flowers are developing, the morning sun would increase the temperature, and so the rate of growth on the east side of the crown first. The high air temperature during midday would allow this temperature of the east side of the cactus to be maintained till late afternoon. The opposite or west side, on the contrary, would probably not reach its maximum temperature till mid-afternoon, or later not long before the evening cooling of the air sets in.

Discussion: Lloyd, MacDougal and McCallum.

Demonstration by Peirce and McMurphy of smelter smoke effects on vegetation.

Thursday, August 5, 10 A.M.

Factors Affecting the Distribution of the Components of the Flora of California: Douglas H. Campbell, Stanford University.

1. The geographical position of California, more or less shut off from the eastern states by its mountains and the deserts, results in a flora very different from that of other parts of the United States. There is an unusual proportion of plants peculiar to the state.

2. The climate of California, especially the coast region, is dominated by the Pacific Ocean—the climate, compared to Atlantic American, is very mild and equable. Topography, rather than latitude, regulates the temperature, *e. g.*, there is apt to be more difference between the maximum of San Francisco and Sacramento, than there is between Eureka and San Diego.

3. Rainfall conditions show a wide range, exercising a great influence upon its floras of different parts of the state. Thus the flora of the redwood belt of the northern coast has probably not a single plant found in the arid district of the southeast, like the Colorado desert.

The prevalence of a dry summer throughout the state results in the prevalence of "Xerophytes," *i. e.*, plants adapted to withstand long periods of drought.

4. The remarkable range of conditions, *i. e.*, temperature, rainfall, elevation, soil, etc., results in a variety of vegetation equalled in very few parts of the world.

5. The principal botanical regions are: (1) The coast flora, (2) the redwood forest belt; (3) the valleys, (4) the mountain region of the Sierra; (5) the deserts of southern California.

6. The plants of California show two distinct types; a southern flora of Mexican origin, and a northern flora more nearly related to the vegetation of the northeastern states. These two floras mingle in the central part of the state, the northern forms following the mountains southward, the southern types mainly occupying the valleys. There is a slight infusion also of Asiatic types from the north.

The Rôle of Physical Features in Determining the Distribution of Plants: Forrest Shreve, Department of Botanical Research, Carnegie Institution of Washington.

The Chapparal and Its Habitat (illustrated): W. S. Cooper, Stanford University.

The broad-sclerophyll vegetation of the Pacific coast, as a dominant type, is confined to the region in which the long dry season, characteristic of the California climate, is combined with low total precipitation and absence of summer fog.

The broad-sclerophyll vegetation comprises two formations: (1) the Oak-Madroña Formation—true forest; and (2) the Chaparral—bush or scrub. Each is subdivided into various associations, the subdivisions being different in different parts of the state.

In the Palo Alto region the Chaparral includes (1) the Adenostoma Association and (2) the Arctostaphylos Association. The former is found

upon south slopes and summits, the latter upon gentle north slopes; and the Oak-Madroña Forest on steep north slopes and in ravine bottoms.

Measurements of evaporation, soil moisture, and soil temperature were made covering a period of eighteen months to determine the habitat differences to which these vegetational differences are due. It was found that the evaporation rate was greatest on summits and south slopes and least on north slopes, as would be expected, but that at the top of the vegetation the differences in evaporation between the aspects were slight. Greater differences were found at the surface of the ground. As to soil moisture, a great difference was found between the two slopes during the rainy season, but this difference gradually decreased during the dry season, almost disappearing at its close.

The conclusion of the study is that the actual physical habitat differences between north and south slopes, though perceptible, are slight, and that evaporation is the fundamental factor. The striking differences seen in the evaporation rates at the surface of the ground, in the soil moisture on the two slopes and at different times of the year, and in the soil temperatures, are due in very large part to the reaction of the vegetation upon the habitat.

Discussion: Abrams and Clements.

Distribution of Cacti with Reference to the Rôle Played by Root Response: W. A. CANNON, Department of Botanical Research, Carnegie Institution of Washington.

In southern Arizona the roots of the cacti lie relatively close to the surface of the soil and are subject to the maximum temperature changes, including the highest temperatures of the summer season. Experiments show that a relatively high temperature of the soil is necessary to the best root growth of the cacti. Owing to the arid foresummer in southern Arizona such root growth takes place in midsummer only, when the seasonal rains come. Since active growth does not occur in the colder portions of the year, although the soil may be moist, the possibility is suggested that the cacti as a family are mainly limited to such regions as have summer rains, other conditions being favorable.

A comparison of the climatic conditions of those portions of America, where the cacti form a prominent portion of the flora, shows that as a matter of fact, they agree in this, that rains are characteristic of the warm season. On the other hand, in regions otherwise apparently favorable, the cacti are either wholly wanting, or they constitute only an insignificant part of the flora.

Climatic Cycles and Succession: F. E. CLEMENTS, University of Minnesota.

Discussion: Abrams, Cooper, Eastwood.

The Diversity of Ecologic Conditions and Its Influence on the Richness of Floras: JOHN W. HARSHBERGER, University of Pennsylvania. (Read by H. M. HALL.)

Ecologic conditions are those which are associated with the environment. They include the influence of climate, soil, physiography, chronology and the life relations of the surroundings. The influence of these conditions on the richness of floras may be considered statistically. The generic coefficient, which is the relativity of genera and species, is inversely proportional to the diversity of the ecologic conditions. The generic coefficient was worked out for the floras of Point Pelee, Ontario; for the pine-barrens of New Jersey; for Hartsville, South Carolina; for the Altamaha Grit Region of Georgia; for Miami, Florida; for the Florida Keys; for the Upper Susquehanna, Pennsylvania; for Lancaster County, Pennsylvania; for Columbia, Missouri; for Jackson County, Missouri; for the Yosemite National Park, California; for the state of Connecticut; for the state of Pennsylvania; for Alabama; for the central Rocky Mountains; for the state of Washington. It was found that Point Pelee with a simple topograph was at one extreme with a generic coefficient of 74.7 per cent. and the Central Rocky Mountains and the southeastern United States at the other extreme with highly diversified and generic coefficients of 23.9 per cent. and 23 per cent. respectively.

Discussion: Clements, Hall, Eastwood.

Plant Succession in the Palo Alto Region: W. S. COOPER, Stanford University.

The Palo Alto quadrangle comprises two distinct physiographic areas: (1) the mountains, covered mainly with residual soils, and (2) the alluvial slope to the bay and beneath it, composed entirely of transported soils derived from the mountains.

On the latter area there is a very perfect succession of vegetational stages, correlated with the building up of the alluvial slope by stream deposition. The stages are as follows: (1) Algæ, in the shallow water of the bay; (2) Salt Marsh; (3) Composite-Willow Formation; (4) Oak Forest, composed mainly of *Quercus lobata* and *Quercus agrifolia;* (5) *Chaparral,* mainly *Adenostoma.* The Salt Marsh replaces the Algæ soon after the soil surface emerges at low tide. The Composite-Willow formation follows with the elimination of the salt from the soil. The Oak Forest appears when there is sufficient feeding ground

for the tree roots, well aerated, above the water table. The Chaparral follows when the distance to the water table becomes so great that the oaks can not obtain sufficient water. The chaparral is permanent because it flourishes independently of moisture supply from the ground water. This succession thus progresses from halophytic to mesophytic conditions and from thence to xerophytic, the final stage being far less mesophytic than the intermediate ones.

In the mountain area successions are short and indistinct and there will be no climax formation for the whole area, short of base levelling. North and south slopes will differ in vegetation as long as they exist, the present dominant vegetation of each aspect being the temporary climax of a short succession.

Discussion: Campbell, Clements, Eastwood.

The Flora of the Desert Basin of the Mohave: S. B. Parish, San Bernardino.

The topography of the Mohave Desert is complex in contrast with that of the Colorado Desert, which is a simple valley, but the climatic and edaphic conditions are practically identical, and are of a pronounced xerophytic character, and consequently such is the character of the plant population. It is, however, locally modified by intrusions through the passes; by the influence of the Colorado River and very markedly by that of the Mohave River. The distribution of the cacti is found to depend upon the amount and reliability of the rainfall. Some account is given of the vegetation in and about the infrequent springs. Certain differences in the respective vegetations of the Mohave and the Colorado Deserts are noticed and shown to depend upon different emigration currents.

Friday, August 6, 10 A.M.

Some Features of the Distribution of the Marine Algæ of the West Coast of North America: W. A. Setchell, University of California.

Discussion: Clements, Lawrence.

Gas Conditions in Nereocystis: T. C. Frye, University of Washington.

Physiological Conditions in the Large Kelps of the Pacific Coast: G. B. Rigg, University of Washington.

The great size and the rapid growth of the four conspicuous kelps of the Pacific coast as well as their potential value as a source of potash fertilizer and of various by-products makes the investigation of their physiological processes a matter of both scientific interest and economic importance.

The growth of the large kelps *Nereocystis leutkeana, Macrocystis pyrifera, Alaria fistulosa* and *Pelagophycus porra* is rapid. Possible factors in this are (1) mechanical stretching by tidal currents (2) great turgidity due to high osmotic pressure in cell sap (3) abundance of potassium, influencing nuclear division.

There is much more potassium than sodium in kelps while the reverse is true in sea water. Possible factors in this are (1) greater permeability of the protoplasm for potassium; (2) a change of potassium compounds into some other form which does not lower the diffusion gradients.

Workers are not agreed as to the source and composition of the gases in the floats of marine algæ, hence definite conclusions as to their part in metabolism are impossible.

Probably carbon dioxide for photosynthesis comes from either the gas in these floats or from carbonates in water, rather than from carbon dioxide in sea water.

Tidal currents may be a factor in photosynthesis by keeping the fronds at the surface. The kelps produce no starch. Their sugars may be a factor in high osmotic pressure.

Studies on the respiratory ratio in marine algæ throw some light on the materials oxidized in respiration.

This paper contributes (1) a summary of the literature bearing on the physiological processes in the large kelps; (2) some hitherto unpublished data with regard to these processes; (3) some suggestions as to possible interpretations of the available data on them; (4) a statement of the more conspicuous gaps in our information in regard to these processes and of the importance of a comprehensive investigation of them.

The Personation and Multiplication of the Fruits of Certain Opuntias: D. S. Johnson, Johns Hopkins University.

The fruits of some few of the cacti, like those of certain Eucalyptoids, differ from those of most other seed plants in not falling from the tree, at the end of the growing season in which they were initiated by the flower. In the exceptional forms mentioned, of which *Opuntia fulgida* is one of the most striking examples, the fruit remains attached, and growing, season after season.

The primary flowers of the season in *Opuntia fulgida* are formed from the lateral buds, or areolæ, of the last year's branches and also from areolæ of the persistent fruits of former seasons. These primary flowers shed the perianth five or six days after the opening and give rise to fruits, which not only remain attached but also give rise, sometimes even before the flower has opened, to

the buds of secondary flowers. The latter in turn bud out Tertiary ones and these initiate flowers of a fourth generation, by the middle of July. All of the four, or more, generations of flowers formed in a season, remain attached and growing for several seasons. In each succeeding season any fruit of the first season's series may give rise to a similar set of primary, secondary, Tertiary and Quaternary fruits. In this way clusters of a hundred fruits, including from ten to fifteen generations, may be formed.

If these persistent fruits remain attached they give rise only to flower buds. If they are broken off and placed on moist soil the same areolæ develop roots and vegetative shoots, and so start a new plant.

Teratology and Phylogeny in the Genus Trillium: R. R. GATES, University of London.

Trillium is a genus of plants which is in an unstable or mutable condition. Many of its variations are teratological. There are frequent records of double flowers appearing, especially in *T. grandiflorum*. In such cases it appears that the same root-stock continues to produce a double flower year after year. Hence a germinal change must have occurred leading to the production of such a rootstock.

A form related to *T. grandiflorum* and known as var. *variegatum* has been studied in Michigan, the Niagara peninsula and near Syracuse, N. Y. This is exceedingly variable, producing in some cases 10 per cent. of abnormal plants which can not reproduce from seed yet which reappear in large numbers each year. This form frequently has long petioles to the leaves, which suggests that *T. petiolatum*, an unrelated species with long petioles, may have originated similarly through a mutation.

In various species of *Trillium* individuals occasionally appear having a whorl of four leaves and their flower parts in 4's instead of in 3's. This is a generic feature of the related Euro-Asian genus *Paris*. Another peculiarity of *Paris* is the elongated connectives, a feature which is a specific character in *T. decumbens* and occasionally appears in teratological specimens of *Trillium*.

Such facts show that variations tend to follow certain paths or lines of cleavage, and these lines must depend upon the structure of the germ plasm. It would appear that the teratological variations of one genus may, under certain conditions, give rise to the stable condition of a derived genus. The paths of variation in a genus may thus indicate tendencies which have found expression in various related genera.

Morphology, Relationship and Sex-determination in Thalocarpus curtisii: F. MCALLISTER, University of Texas.

The morphology of *Thallocarpus Curtisii* is the same as that of the Riccias with two minor exceptions. The rhizoids lack the peg-like thickenings characteristic of the Marchantiales, and the four spores of the tetrad adhere to form a spore ball as is the case with some of the *Sphærocarpus* species. The gametophyte seems to be the same in structure as the spongy Riccias. The sporophyte has no traces of a foot nor of sterile nutritive or elater-like cells. It is difficult to see how this liverwort was ever included with the *Sphærocarpos* forms.

The four spores of the tetrad form, on germination, two male and two female plants. In this respect there is a similarity to *Sphærocarpus Texanus* and *S. Californicus*.

Quasi-experimental Formation of Æcidia in Cotton Leaves: F. E. LLOYD, McGill University. (Read by title only.)

Small plants of cotton were grown in 3-inch pots for over one year, and subjected to severe physiological drought, moderated sufficiently to keep them alive. Plentiful watering, aided by rising temperatures, resulted in forcing growth in many lateral shoots, and these produced a large proportion of abnormally shaped leaves. The whole series presented a variety of shapes, the simplest showing a mere constriction across one or more lobes. Foldings, lobulations and concrescences entered in to accentuate the departure from the normal, which, passing through stages with ill-formed and only partially separated ascidia, culminated in perfect ascidia raised on their proper petioloid supports.

Such abnormalities appear to rise from identical conditions with fasciations and indeed both these kinds of aberrancy are found associated in the same plant (*Fraxinus, Spinacea*). They have been shown to be inherited in some cases.

Desiccation and Starvation of a Succulent: D. T. MACDOUGAL, E. R. LONG, J. G. BROWN, Dept. Bot. Research, Carnegie Inst. of Wash. (Read by title only.)

A number of large sound individuals of *Echinocactus*, and of several joints of *Opuntia* were deprived of water supply, and compelled to carry on existence at the expense of accumulated water and food-material. Some of the preparations were exposed to the full illumination to which they were accustomed, and others were placed in diffuse light obtaining differential effects in water-loss, respiration, disintegration of acids, and photo-

synthesis. The principal generalizations arising from the studies are as follows:

An *Echinocactus* in the open may survive no more than two years at the expense of its surplus food material and water. Similar plants in diffuse light have been seen to be sound after six years of starvation, although the effects were marked.

Non-reducing soluble sugars which are present in only minute proportions if at all in normal *Echinocacti*, are noticeable constituents of the sap of desiccated plants.

Extended desiccation and starvation made no alteration in the integument of *Echinocactus*, but in a plant which had been thus treated for 73 months the cuticle was thicker than the normal, while the outer wall of the epidermal cells was thinner. Cytoplasm and nuclei in the epidermal system were reduced but new cork layers were being formed as in the normal. Division was seen in the epidermal layer at the bottom of the grooves of the stem. The stomata remained permanently open and many were in a collapsed condition. Guard cells of stomata differed from the normal in having anterior walls thinner as compared with the posterior walls.

The palisade layer was thinner than in normal plants of Echinocactus. The cytoplasm was reduced to small masses in the angles of the cells, and the nuclei were variously deformed and reduced in size. Vacuoles had disappeared from the nucleoplasm and a thickened granular layer was present in the peripheral portion.

The most pronounced effects of desiccation and starvation were exhibited by the cortex of *Echinocactus*. The changes noted as having been seen in the palisade tissues were followed by the entire disappearance of the protoplasts and the hydrolyzation of the cell masses formed lacunæ as large as 8 cubic centimeters.

On Wednesday, August 4, Section G and the Biological Society of the Pacific held a dinner at the Hotel Sutter, San Francisco.

W. J. V. Osterhout, *Secretary*

SOCIETIES AND ACADEMIES

BIOLOGICAL SOCIETY OF WASHINGTON

The 544th meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club Saturday, November 6, 1915, called to order by President Bartsch, with 90 persons present.

On recommendation of the council, Gilbert F. Bateman, Trinidad, Colorado, was elected to active membership.

The first paper of the regular program was by O. P. Hay, "A New Pleistocene Sloth from Texas." Dr. Hay discussed the finding in Texas of a new member of the genus *Nothrotherium*. This discovery extends the range of the genus from South into North America. The specimen was exhibited and remarks were made on the interrelationships and distribution of the living and fossil American Edentates.

The second paper was by J. N. Rose, "Botanical Explorations in South America." Dr. Rose gave an account of his botanical explorations in South America. He outlined first the field work which he and Dr. N. L. Britton had planned in connection with the cactus investigations of the Carnegie Institution of Washington and then proceeded to describe the great cactus deserts of South America which he had visited. During his last trip to South America he spent six weeks in the state of Bahia, Brazil, six weeks in the state of Rio de Janeiro, Brazil, and three weeks in Argentina. Large collections were obtained. Many living plants were sent back to the United States for cultivation. The living collection is now on exhibition in the New York Botanical Garden. Several remarkable generic types of cacti were discovered. Dr. Rose's paper was illustrated by numerous lantern slides of regions visited, of cacti in their native environment; and by many interesting botanical specimens.

The last paper of the evening was by Dr. L. O. Howard, "Some Biological Pictures of Oahu (Hawaii)." Dr. Howard showed a large number of lantern slides from photographs made by him during a short stay the past summer on the island of Oahu. Special emphasis was laid on those which dealt with agricultural problems and economic entomology, many of which are peculiar to the Hawaiian Island.

M. W. Lyon, Jr.,
Recording Secretary

THE NEW ORLEANS ACADEMY OF SCIENCES

The regular meeting of the academy was held in Tulane University on Tuesday, November 16, 1915, Dr. Gustav Mann, president, in the chair.

The paper of the evening was by Dr. W. H. Dalrymple, of the Louisiana State University, on "The History of the Cattle Tick Fight in Louisiana." Dr. Dalrymple gave a brief history of the fight in Louisiana, first, by individual effort, then by state effort, and, finally, by federal aid. The paper proved of considerable interest and there was much discussion at the close.

R. S. Cocks, *Secretary*